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Prebiotic and probiotic knowledge and consumption in collegiate athletes

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Abstract

The purpose of this study was to investigate gastrointestinal disturbances in collegiate athletes and their knowledge of gastrointestinal health, or lack thereof, specifically pertaining to nutrition choices including prebiotic fiber and probiotic foods, sources, and supplements. Student-athletes at the division one level endure rigorous training for competition. Although one may have competent knowledge on the importance of fueling their body for their sport, there may be gaps in understanding the digestive mechanisms of their diet, importance of a diverse gut microbiome, and subsequent nutrient uptake. This study and questionnaire explored the relationship between gastrointestinal (GI) disturbances a student-athletes may experience and the level of knowledge an individual has of gut health maintenance, and how that impacts the dietary choices they make concerning prebiotic and probiotic consumption. This study showed there was a minimal to slight increase in probiotic and prebiotic knowledge in the last decade. Results revealed that GI disturbance expressed had no significant relationship to one's level of knowledge and dietary consumption of prebiotic and probiotic foods. However, the population may still benefit from further education on this topic, and raise overall awareness on the prevalent health benefits and ways to achieve a rich and diverse gut microbiome.

Background

Previous studies conducted show that 30 to 70 percent of athletes experience some type of gastrointestinal (GI) disturbance, most relevant amongst endurance athletes and weight lifters (1). With such a remarkable statistic, investigation into a possible underlying factor is essential in addressing this disturbance that may be affecting an athlete's performance and overall well-being. Although GI irritation may be caused from various physiological interactions, the relationship between the state of the gut microbiome and physical discomfort may call for further investigation.

The small intestine, previously stated as the gut, is the site where key nutrients and water are further digested and absorbed into the bloodstream to travel to various destinations in the body (2). Within the small intestine is housed a vast and diverse microbe community of beneficial bacteria that exhibits a commensal relationship with the human body. Investigative evidence has shown that these microorganisms impact the body in more ways than one including metabolic, endocrine, neuronal, and immune function. More recently, studies have increasingly shown that the gut microbiota has been seen to act endocrine in function to help produce and regulate short-chain fatty acids (SCFA), neurotransmitters, and hormones; all of which also have a considerable impact on an athlete's levels of fatigue, motivation and mood (3). In the absence of healthy and diverse gut microbiota, it is found that numerous health issues arise including general discomfort, nutrient uptake deficiency, depression, and can lead to further health ailments such as arthritis, obesity, type I and II diabetes, arterial stiffness and impaired immune response (4). Interestingly, a study conducted compared the influence of genetics and diet concerning mice gut microbiota, and found that dietary choices accounted for 57% of gut microbiota changes as compared to genetic influence of no more than 12% (5). Although little

research has been done on humans in this topic, past research has shown the possible influence dietary habits have on increasing the diversity of the gut microbiome.

Within the small intestine, microorganisms feed on micro- and macronutrients humans ingest. When the colonized microbes feed on the nutrients they in turn release byproducts that include short-chain fatty acids (SCFA) and lactate. SCFAs are specifically released from bacteria when prebiotic fibrous foods are ingested. The roles SCFAs and lactate play are extensive and promote homeostasis in the body by increasing oxygen consumption and urinary output, reducing energy expenditure, and also stimulating the sympathetic nervous system (6). SCFAs and lactate collectively regulate the pH of the gut, help control appetite, prevent leaky gut, and regulate the immune system by combating inflammation, pathogens, and cancerous activity (7) as well as support tissue growth and repair. An additional factor to note is that an abundance and variation of SCFAs needed to perform all previous functions stated above are indicative of numerous and highly diverse bacteria within the gut microbiome (8).

A microbiome rich in bacterial diversity acting as an exocrine organ to release SCFAs and lactate as stated above may be beneficial to collegiate athletes that endure rigorous, long term training. Studies have shown that athletes engaging in highly aerobic, endurance activity are at an increased risk of leaky gut and intestinal wall permeability due to exercise-induce stress. Increase in permeability is caused by blood being pulled away from the GI tract to other organ systems such as skeletal muscle, respiratory, and cardiovascular during high levels of exercise. A decrease in blood supply is also accompanied by inflammation and can lead to intestinal wall damage (3). Intestinal wall damage is the result of the loosening of tight junctions releasing pathogens and toxins into the blood stream, causing a larger inflammatory response throughout the body (9). However, the health of the intestinal wall and its role to act as a barrier,

prohibiting the passage of harmful substances is greatly contributed to SCFAs produced by beneficial bacteria.

As previously mentioned, SCFAs and lactate are the byproducts of the food that bacteria within the gut ingest. This food, commonly referred as a *prebiotic,* had been defined by the International Scientific Association for Probiotics and Prebiotics as, "a substrate that is selectively utilized by host microorganisms conferring a health benefit. (10)" Foods prebiotic in nature are often high in fiber. Prebiotic food sources include whole grains, onion, garlic, banana, and soy (11). Fiber has been show to pass through the GI tract undigested provides energy to microbial bacteria to maintain the commensal relationship between them and the human host (12). Supporting evidence also shows that an increase in dietary fiber has also been linked to an increase in microbial diversity and richness in those who showed to have a lack of diversity of bacteria within their gut (13).

In the last decade, the term and use of *probiotic* supplements has become increasingly prominent in nutritional science. The International Scientific Association for Probiotics and Prebiotics defines probiotic as "live microorganisms that, when administered in adequate amounts, confer a health benefit on the host.(10)" Supplementation has been prescribed by physicians to those who experience frequent GI disturbances, and subsequently struggle to maintain a rich and diverse gut microbiome. When ingested, probiotics have the potential to positively impact diversity of colonic microbial community and aid in digestion, outcompete harmful pathogens, and restore gut flora impacted by the use of antibiotics (14).

The consumption of prebiotic and probiotic foods and supplements amongst athletes may have positive physiological effects such as minimizing gastrointestinal disturbances, as well as enhancing performance and recovery. Although minimal research conducted on the direct

relationship between the health of one's gut microbiome and physical performance, research has indicated that higher cardiorespiratory fitness correlated with greater microbial diversity in fecal sampling and that microbial diversity was a more prominent predictor of fitness as compared to age, sex, or body mass index (15). Increasing caloric intake of carbohydrates and proteins is emphasized in the athletic community in order to meet the energy needs for competition. Additional knowledge that may not be as commonly discussed is that 10-30% of energy harvested from these foods sources is done by the gut microbiota, and if not, would be eliminated from the body yielding a loss in potential energy stores (16). This further shows the importance of maintaining a rich and diverse gut microbiota through inclusion of prebiotic and probiotic sources in an athlete's diet.

The topic surrounding microbial bacteria influence on human digestion and metabolism has become more prominent in the scientific community in the last decade. However, this increase in knowledge may not extend to the collegiate athlete atmosphere and beyond. Evidence that may support this claim comes from a study conducted evaluating the perception of medical science students towards probiotics. This study found that only 59.7% of students with a background in health sciences could identify the health effects of probiotics. In addition, basic knowledge concerning common forms of probiotic products available in the market was lacking. Additional research conducted across numerous countries found that the ability to define the term *probiotic* ranged from 43.9-83% (17). Studies have shown that while a majority of athlete's with healthy attitudes about their behaviors of eating, they had low knowledge scores, and of the scores reported, 35% knew of the health risks associated with low fiber intake and only 42% were able to identify a meal high in fiber (18).

As previously mentioned, 30 to 70% of athletes suffer gastrointestinal disturbances while also possibly exhibiting a lack of knowledge in nutrition, needing to be further investigated. This study will determine the probiotic and prebiotic knowledge of student-athletes. Also, this study explores the relationship between gastrointestinal disturbances and the level of knowledge an individual has on prebiotic and probiotic sources, and the amount of prebiotic and probiotic foods implemented into their diet. Results may reveal that student-athletes at the NCAA Division One level suffering from gastrointestinal disturbances is influenced by an absence of knowledge and diet containing prebiotic and probiotic foods.

Methods

Subjects

Participants were recruited through approval from Western Michigan University Institutional Review Board and Western Michigan University Athletic Department staff through email, word of mouth, and phone communication. Inclusion criteria consisted of identifying as a Western Michigan University student-athlete above the age of 18, have an understanding that the study is voluntary, and have the understanding that they may choose to terminate their participation at any time and their answers will be excluded from the results. Exclusion criteria consisted of a refusal to give informed consent, women who are pregnant, and those with a health history of cancer, Type 1 and Type II diabetes. 74 Western Michigan University student-athletes took part in the study, agreeing to the informed consent. One participant did not agree to the informed consent and seven participants did not complete the survey in full.

Procedure

After informed consent was signed and each participant had a thorough knowledge of the importance of the study, they took a three part, 22 question, online questionnaire using the software Qualtrics. Part one, demographics, asked of demographic information including age, affiliated sport, and place of living. Part two, knowledge, inquired about current knowledge the subject had on microbial diversity, definitions of probiotic microorganisms and prebiotic fiber, health benefits, daily recommended intake, and prebiotic and probiotic food sources. This section was intended to be taken without the help of others or internet sources. Part three, health and diet, asked of personal health history concerning gastrointestinal disturbances and frequency, as well as habitual dietary decisions and supplement use. The questionnaire did not take subjects more than ten minutes to complete and was available to student-athletes during a 30 day period.

Instrumentation

The study to support or reject the hypothesis was completed using a questionnaire given remotely, online to Western Michigan University student-athletes through Qualtrics software. The questions asked in the questionnaire are as followed.

Part One: Demographics

Q1. What is your age?

- 18
- 19
- 20
- 21
- 22 or older I prefer not to answer

Q2. Which of the following sports do you play?

- Baseball
- Basketball
- Cross Country
- Track and Field
- Football
- Golf
- Gymnastics
- Hockey
- Soccer
- Tennis
- Volleyball
- I prefer not to answer

Q3. Which of the following describes your living arrangements?

- On campus with dining plan
- Off campus apartment
- Off campus apartment using university dining plan
- Off campus family home I
- prefer not to answer

Part two: Knowledge
The following questions must be taken alone, without the help of others or the internet.

Q4. What is the daily recommended intake for fiber in your diet?

- 3-5 grams
- 10-15 grams
- 25-30 grams
- 50-70 grams

Q5. True or False. It is bad to have a wide variety of bacteria living in your gut.

- True
- False

Q6. Which of the following describes the term "probiotic" ?

- Live organisms that benefits your health
- A substance that organisms use to cause health benefits
- Biological macromolecule that benefits your health

Q7. Select all of the following sources of probiotic foods:

- Greek yogurt
- regular yogurt
- kefir
- kombucha
- cottage cheese
- banana
- Jerusalem artichoke
- cheddar cheese
- dark chocolate

Q8. Which of the following are true of probiotics? Select all that apply.

- improves immune response
- prevents antibiotic related diarrhea
- all probiotic supplements are approved by the FDA
- 10^8 - 10^9 probiotic microorganisms should be consumed every 6 weeks to show effect
- displays antimicrobial activity against pathogenic bacteria
- reduces cholesterol levels

Q9. Which of the following describes the term "prebiotic"?

- Live organisms that benefits your health
- A substance that organisms use to cause health benefits
- Biological macromolecule that benefits your health

Q10.Select all of the following sources of prebiotic foods:

- oats
- asparagus
- soybeans
- wheat
- dark chocolate
- pickles
- legumes
- onions
- sauerkraut

Q11. Which of the following are the health benefits of prebiotics? Select all that apply.

- improves immune system
- slows down metabolism
- increases calcium absorption
- reduces inflammation
- decrease in allergies
- always aids in weight loss

Q12. True or false. Higher levels of physical activity correspond to greater microbial diversity in the gut.

- True
- False

Part three: Individual health history and diet

Q13.Have you ever previously been clinically diagnosed with any of the following digestion related conditions? Select all that apply.

- Chron's disease
- Irritable bowel syndrome
- Celiac Disease
- Gluten intolerance
- Dairy intolerance
- Yes, but not listed
- No
- I prefer not to answer

Q14. Do you currently experience any of the following symptoms on a regular basis? Select all that apply.

- Upset stomach
- Gas
- Bloating

- Constipation
- Diarrhea
- Heartburn
- I do not experience any of these symptoms
- I prefer not to answer

Q15. If you answered yes in the previous question, how often do you experience the selected symptom?

- I did not answer yes
- Everyday
- 2-3 times per week
- 4-5 times per week
- 5+ timers per week
- I prefer not to answer

Q16. Have any of the previous selected symptoms prevented participation in a game, match, or training session?

- Yes, but rarely
- Yes, frequently
- Never
- I prefer not to answer

Q17. How often do you eat fast food or take out per week?

- Rarely or less than once per week
- 2-3 times per day
- Everyday
- 2-3 times per week
- 4-5 times per week
- 5+ times per week
- I prefer not to answer

Q18. Which of the following foods do you regularly incorporate into your diet? Select all that apply.

- bananas
- garlic
- whole oats
- onions
- Jerusalem artichoke
- soy
- none of the above
- I prefer not to answer

Q19. Which of the following foods do you regularly incorporate into your diet? Select all that apply.

- yogurt
- kombucha
- sauerkraut
- cottage cheese
- cheddar cheese
- pickles
- none of the above
- I prefer not to answer

Q20. Do you currently take a probiotic supplement?

- Yes
- No
- I prefer not to answer

Q21. Do you currently take a fiber or prebiotic supplement?

- Yes
- No
- I prefer not to answer

Q22. Do you currently take a multivitamin, pre-workout, protein, creatine, or any other supplements?

- Yes
- No
- I prefer not to answer

Data Analysis

The study was designed to test the level of knowledge and define the health benefits and sources of prebiotic and probiotic foods and supplements amongst student-athletes. The questionnaire also sought to show variation and frequency of food choices of total participants. Lastly the questionnaire revealed the presence and types of GI disturbances and frequency amongst the sample.

The hypothesized question, student-athletes at the NCAA Division One level suffering from gastrointestinal disturbances is influenced by an absence of knowledge and diet containing prebiotic and probiotic foods, was tested through the use of three individual Chi-Square Test of Independence. The Chi-Square tests were generated to test the significance difference between two subsets of the sample, those without GI disturbances (Group A) and those with (Group B). Data was considered significant at $p \leq 0.05$. The data collected and implemented into a Chi-Square Test would either reject, or failure to reject, the null hypothesis (H_0) stating that GI symptoms are independent upon variable 1, (Var. 1) knowledge scores, and variable 2 (Var. 2) diet. The alternative hypothesis (H_1) stated GI symptoms are dependent upon Var. 1, knowledge scores, and Var. 2, diet. Variables 1 and 2 were cross analyzed with student-athletes without GI symptoms, Group A (n=30), and student-athletes with GI symptoms, Group B (n=37).

The first Chi-Square Test with observed values examined the relationship significance between Var. 1 and Var. 2 as seen in Tables 4 and 5. Furthermore, demographic data collected was used to compare subsets of the population, place of living, to knowledge diet, and GI disturbances as seen in Figures 1-3.

The second Chi-Square Test with observed values examined Var 1. and Groups A and B, results are represented in Table 6 and 7. Knowledge scores were computed based on questions 7 and 10 from the questionnaire addressing the sources of probiotic and prebiotic foods. The total, combined points possible to answer correctly was scored out of 18. Participants selecting 0-6 correct answers were labeled as “low” , those selecting 7-12 correct answers were labeled as “moderate” (mod.) and those selecting 13-18 correct answers were labeled as “high.”

The third Chi-Square Test with observed values examined Var. 2 and Groups A and B represented in Tables 8 and 9. Diet scores were computed based on questions 18 and 19 from the

questionnaire addressing probiotic and prebiotic foods implemented into each participant's diet. The total, combined points possible to select was scored out of 12. Participants selecting 0-4 foods were labeled as "low" , those selecting 5-8 foods were labeled as "moderate" (mod.) and those selecting 9-12 foods were labeled as "high," however, no participants selected 9-12, so the "high" category was not included in Tables 6 and 7.

Results

Tables 1-3 represents the sample count and percent of population for selection per each questionnaire answers: demographics, knowledge, and health and diet.

Demographics

Table 1 represents questions one through three, focusing on demographics. Age range amongst the population was 18-22, with the average of 20.18 ± 1.42. The 74 participant sample was primarily saturated in sports of soccer (30) and baseball (16).

Table 1: Demographic information (N = 73)

Age	**Count**	**Percent (%)**
18	12	16.4
19	12	16.4
20	19	26.0
21	11	15.1
22	19	26.0
Sport	**Count**	**Percent (%)**
Baseball	16	21.6
Basketball	0	0.0
Cross Country	3	4.1
Football	1	1.4
Golf	4	5.4
Gymnastics	3	4.1
Hockey	0	0.0
I prefer not to answer	4	5.4
Soccer	30	40.5
Softball	4	5.4
Tennis	0	0.0
Track and Field	4	5.4
Volleyball	7	9.5
Living Arrangements	**Count**	**Percent (%)**
On campus with dining plan	16	21.9
Off campus apartment	44	60.3
Off campus family home	13	17.8

Knowledge

Nine of the following questions focused on concepts including probiotic and prebiotic definitions, sources, and benefits or important aspects to the intervention. The results of the survey, seen in Table 2 revealed that student-athletes had acceptable knowledge in the importance of the diversity of the microbiome (84.3%), impact of physical activity (75.7%), and prebiotic and probiotic benefits with an average score 64-66% of correct options selected. The study sample had deficient knowledge in topics concerning prebiotic (45.7%) and probiotic (53.7%) terms, daily recommended intake of fiber (54%), prebiotic (55%) and probiotic (51%) sources.

Table 2: Knowledge questions

Q4: What is the daily recommended intake for fiber in your diet?	**Count**	**Percent (%)**	**N**
3-5 grams	3	4.3	70
10-15 grams	27	38.6	70
25-30 grams	38	54.3	70
50-70 grams	2	2.9	70
Q5: True or False. It is bad to have a wide variety of bacteria living in your gut.	**Count**	**Percent (%)**	**N**
True	11	15.7	70
False	59	84.3	70
50-70 grams	2	2.9	70
Q6: Which of the following describes the term "probiotic" ?	**Count**	**Percent (%)**	**N**
Live organisms that benefits your health	37	52.9	70
A substance that organisms use to cause health benefits	13	18.6	70
Biological macromolecule that benefits your health	20	28.6	70
Q 7: Select all of the following sources of probiotic foods:	**Count**	**Percent (%)**	**N**
Greek yogurt	66	89.2	74

kombucha	52	70.3	74
cottage cheese	40	54.1	74
banana	30	40.5	74
regular yogurt	29	39.2	74
dark chocolate	23	31.1	74
cheddar cheese	19	25.7	74
kefir	18	24.3	74
Jerusalem artichoke	18	24.3	74
Q8: Which of the following are true of probiotics? Select all that apply.	**Count**	**Percent (%)**	**N**
improves immune response	64	86.5	74
displays antimicrobial activity against pathogenic bacteria	49	66.2	74
reduces cholesterol levels	34	45.9	74
prevents antibiotic related diarrhea	29	39.2	74
10^8 - 10^9 probiotic microorganisms should be consumed every 6 weeks to show effect	25	33.8	74
all probiotic supplements are approved by the FDA	10	13.5	74
Q9: Which of the following describes the term "prebiotic"?	**Count**	**Percent (%)**	**N**
Live organisms that benefits your health	13	18.6	70
A substance that organisms use to cause health benefits	32	45.7	70
Biological macromolecule that benefits your health	25	35.7	70
Q10: Select all of the following sources of prebiotic foods:	**Count**	**Percent (%)**	**N**
soybeans	52	70.3	74
oats	46	62.2	74
wheat	37	50.0	74
legumes	35	47.3	74
asparagus	34	45.9	74
pickles	21	28.4	74
sauerkraut	21	28.4	74
onions	20	27.0	74
dark chocolate	16	21.6	74

Q11: Which of the following are the health benefits of prebiotics? Select all	Count	Percent (%)	N
reduces inflammation	57	77.0	74
improves immune system	56	75.7	74
increases calcium absorption	47	63.5	74
decrease in allergies	20	27.0	74
slows down metabolism	18	24.3	74
always aids in weight loss	14	18.9	74
Q12: True or false. Higher levels of physical activity correspond to greater microbial diversity in the gut.	**Count**	**Percent (%)**	**N**
True	53	75.7%	70
False	17	24.3%	70

Health and Diet

Ten of the following questions focused on previous clinical history, GI disturbance type and frequency, dietary choices, and supplementation practices amongst the student-athlete sample. As seen in Table 3, 25.7% of student-athletes experience a clinically diagnosed GI condition. 60.8% reported experiencing GI disturbances on a regular basis, and of those reported, 6-11.9% experience the symptoms at a frequency of 5+ days per week to everyday. However, 80.6% of student-athletes selecting symptoms also stated that the symptoms have never impacted training or competition. 19% of the sample reported that GI disturbance at some point had impacted participation, while 3% said that disturbances frequently impacted participation.

As seen in Table 3, participants on average selected 1.71 ±1.122 prebiotic foods and 1.49 ±1.03 probiotic foods out of six possible options included into their everyday diet. The highest selected prebiotic food was banana at 66.2% and highest selected probiotic food was yogurt at 56.8%. Addressing fast-food and take-out practices in the student-athlete diet, 33.7% eat fast-food or take-out each day. The survey also showed 52.2-68.6% difference in the sample of those that take other forms of supplements compared to probiotics and prebiotic supplements.

Table 3: Health and Diet Questions

Q13: Have you ever previously been clinically diagnosed with any of the following digestion related conditions? Select all that apply.	**Count**	**Percentage (%)**	**N**
No	55	74.3	74
Irritable bowel syndrome	6	8.1	74
Dairy intolerance	5	6.8	74
Gluten intolerance	4	5.4	74
Yes, but not listed	3	4.1	74
Chron's disease	1	1.4	74
Celiac Disease	1	1.4	74
I prefer not to answer	1	1.4	74
Q14: Do you currently experience any of the following symptoms on a regular basis? Select all that apply.	**Count**	**Percentage (%)**	**N**
I do not experience any of these symptoms	29	39.2%	74
Bloating	25	33.8%	74
Gas	22	29.7%	74
Upset stomach	17	23.0%	74
Diarrhea	8	10.8%	74
Constipation	6	8.1%	74
Heartburn	1	1.4%	74
I prefer not to answer	1	1.4%	74
Q15: If you answered yes in the previous question, how often do you experience the selected symptom?	**Count**	**Percentage (%)**	**N**
I did not answer yes	29	43.3%	67
Everyday	8	11.9%	67
2-3 times per week	15	22.4%	67
4-5 times per week	10	14.9%	67
5+ timers per week	4	6.0%	67
I prefer not to answer	1	1.5%	67
Q16: Have any of the previous selected symptoms prevented participation in a game, match, or training session?	**Count**	**Percentage (%)**	**N**
Yes, but rarely	10	14.9%	67
Yes, frequently	2	3.0%	67

Never	54	80.6%	67
I prefer not to answer	1	1.5%	67
Q17: How often do you eat fast food or take out per week?	**Count**	**Percentage (%)**	**N**
Rarely or less than once per week	36	53.7%	67
2-3 times per day	1	1.5%	67
2-3 times per week	24	35.8%	67
4-5 times per week	5	7.5%	67
I prefer not to answer	1	1.5%	67
Q18: Which of the following foods do you regularly incorporate into your diet? Select all that apply.	**Count**	**Percentage (%)**	**N**
bananas	49	66.2%	74
whole oats	32	43.2%	74
onions	22	29.7%	74
garlic	20	27.0%	74
soy	5	6.8%	74
Jerusalem artichoke	0	0.0%	74
I prefer not to answer	0	0.0%	74
Q19: Which of the following foods do you regularly incorporate into your diet? Select all that apply.	**Count**	**Percentage (%)**	**N**
yogurt	42	56.8%	74
cheddar cheese	38	51.4%	74
pickles	20	27.0%	74
kombucha	4	5.4%	74
cottage cheese	4	5.4%	74
sauerkraut	1	1.4%	74
I prefer not to answer	0	0.0%	74
Q20: Do you currently take a probiotic supplement?	**Count**	**Percentage (%)**	**N**
Yes	15	22.4%	67
No	52	77.6%	67
Q21: Do you currently take a fiber or prebiotic supplement?	**Count**	**Percentage (%)**	**N**
Yes	4	6.0%	67
No	62	92.5%	67

I prefer not to answer	1	1.5%	67
Q22: Do you currently take a multivitamin, pre-workout, protein, creatine, or any other supplements?	**Count**	**Percentage (%)**	**N**
Yes	50	74.6%	67
No	17	25.4%	67

Cross Comparison

The original sample size of 74 was lowered to 67 for the following tests due to missing answers and lack of congruency for individual survey responses. The first relationship explored to reject or fail to reject H_0 was between knowledge (Var. 1) and diet (Var. 2) to see if there was significant effect of knowledge of prebiotic and probiotic on diet choices. The p-value found through a Chi-Square Test as seen in Tables 4 and 5 yielded a result of $p=0.42$, showing no significance or no reliable relationship to report. The second relationship explored to reject or fail to reject H_0 was tested to cross compare knowledge (Var.1) and GI disturbance amongst groups with no symptoms (Group A) and with symptoms (Group B). Tables 6 ad 7 exhibit the Chi-Square Test with a computed $p=0.66$, yielding no significant relationship. The third relationship explored was between diet (Var. 2) and GI disturbance amongst Group A and B. Tables 8 and 9 exhibit the Chi-Square Test with a computed p-value = 0.31, yielding no significant relationship.

Table 4: Observed frequency (f_0) of Var. 1 vs. Var. 2

Observed (f_0)	Var 1: Low	Var 1: Mod	Var 1: High	Total
Var 2: Low	3	41	8	**52**
Var 2: Mod	0	11	4	**15**
Total	**3**	**52**	**12**	**67**

Table 5: Chi-Square of Var. 1 vs. Var. 2

Chi-Square	Var 1: Low	Var 1: Mod	Var 1:High	Total
Var 2: Low	0.19	0.01	0.19	**0.39**
Var 2: Mod	0.67	0.04	0.64	**1.35**
Total	**0.87**	**0.05**	**0.83**	**1.74**

(p-value= 0.42)

Table 6: Observed frequency (f_0) of Var. 1 vs. Group A and B

Observed (f_0)	Low	Moderate	High	Total
Group A	2	22	6	**30**
Group B	1	30	6	**37**
Total	**3**	**52**	**12**	**67**

Table 7: Chi-Square of Var. 1 vs. Group A and B

Chi-Square	Low	Moderate	High	Total
Group A	0.32	0.07	0.07	**0.46**
Group B	0.26	0.06	0.06	**0.38**
Total	**0.58**	**0.13**	**0.13**	**0.84**

(p-value= 0.66)

Table 8: Observed frequency (f_0) of Var. 2 vs. Group A and B

Observed (f_0)	Var 1: Low	Var 1: Mod	Var 1: High	Total
Var 2: Low	3	41	8	**52**
Var 2: Mod.	0	11	4	**15**
Total	**3**	**52**	**12**	**67**

Table 9: Chi-Square of Var. 2 vs. Group A and B

Chi-Square	Var 1: Low	Var 1: Mod	Var 1:High	Total
Var 2: Low	0.19	0.01	0.19	**0.39**
Var 2: Mod	0.67	0.04	0.64	**1.35**
Total	**0.87**	**0.05**	**0.83**	**1.74**

(p-value= 0.31)

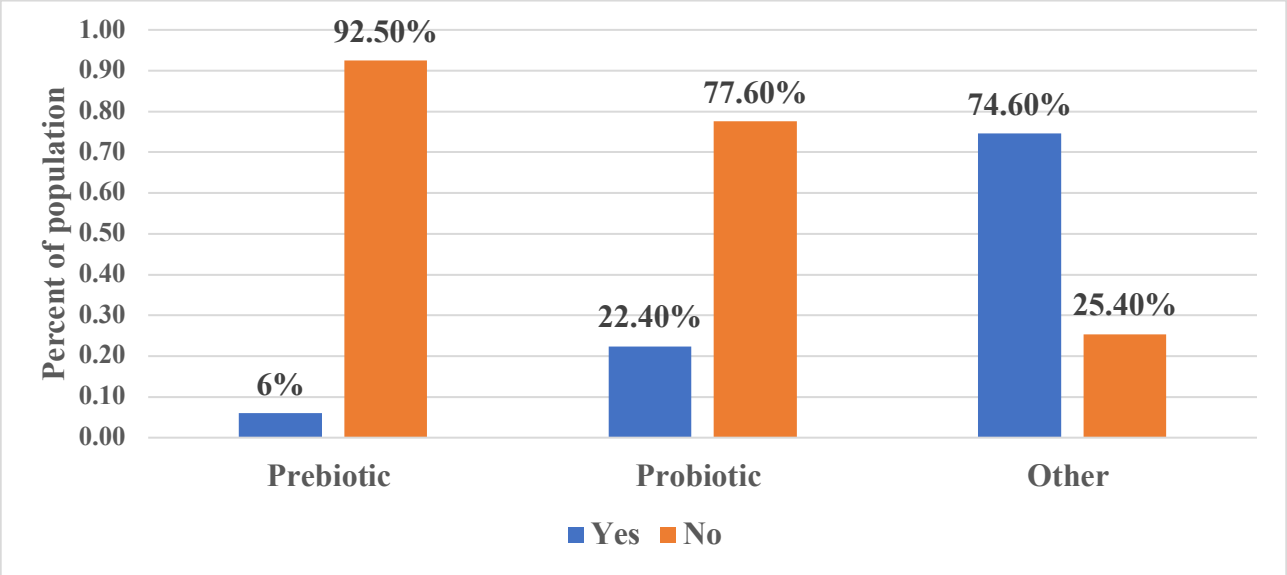
Table 10: Prebiotic and Probiotic Term vs. Age

Age	Probiotic correct answer	Prebiotic correct answer
18	16.2%	12.5%
19	18.9%	12.5%
20	∧ 35.1%	28.1%
21	∨ 5.4%	18.8%
22 or older	24.3%	28.1%

Table 11: Correct DRI of Fiber vs. Age

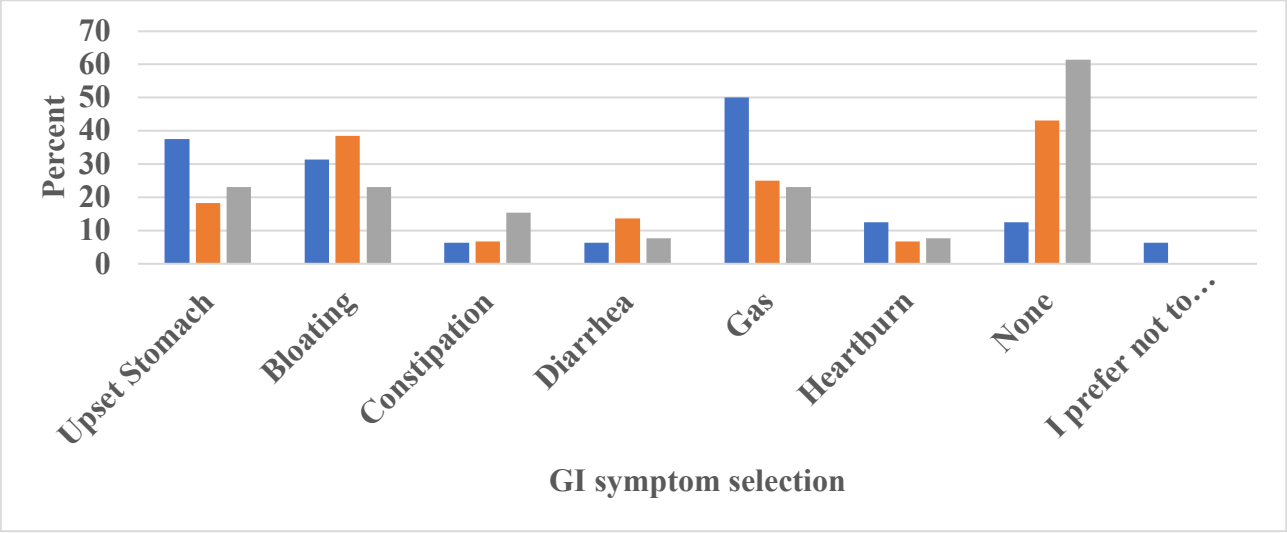
Age	Correct Number	Percent of population correct
18	6	50.0%
19	5	45.5%
20	8	47.1%
21	3	27.3%
22 or older	16	84.2%

Figure 1: Supplementation Usage



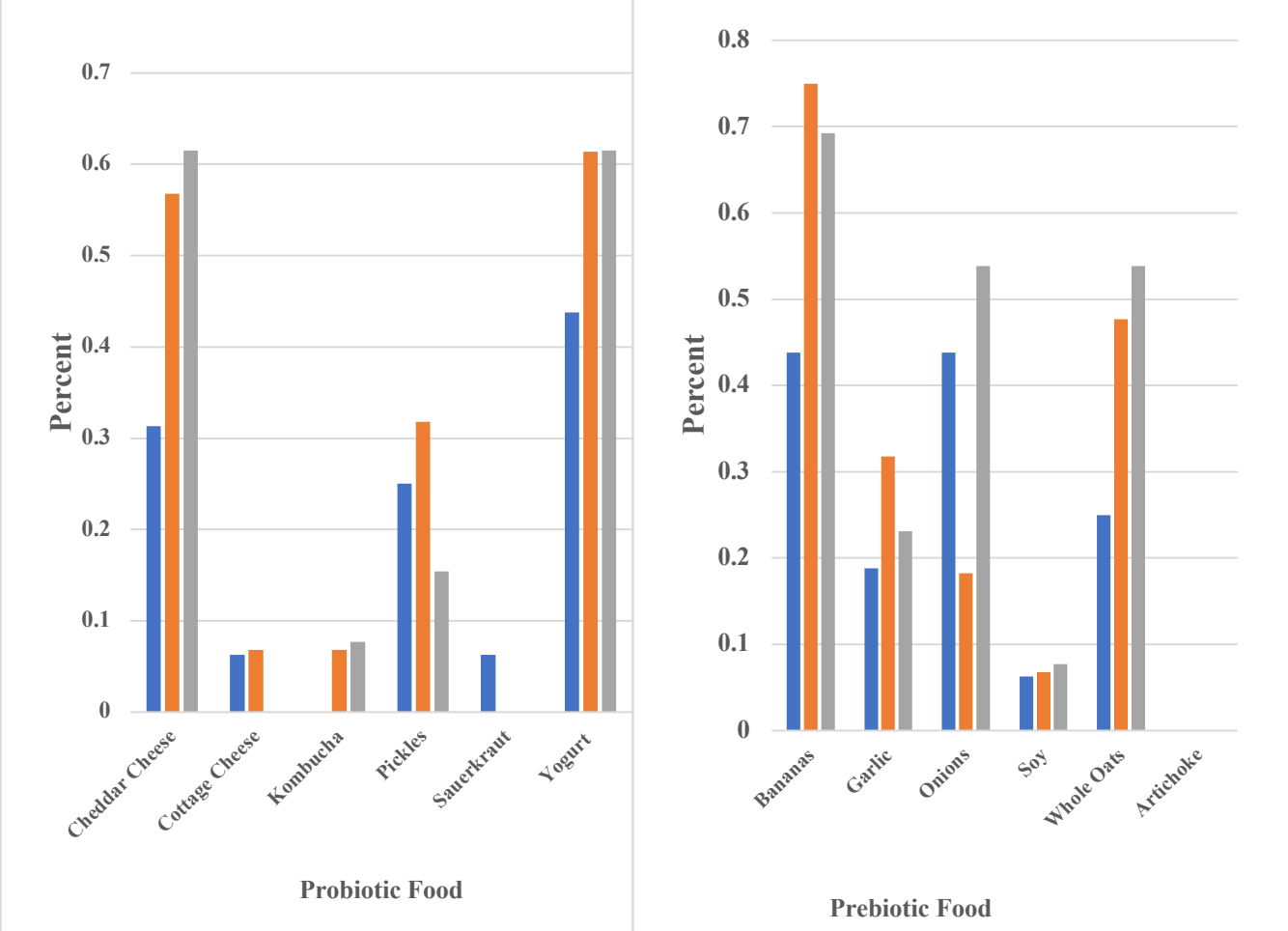
(Key: Blue = selected yes, Orange = selected no. N = 73)

Figure 2: Place of living vs. GI symptoms



(Key: Blue = On campus living, Orange = Off campus apartment, Gray = Off campus family home. N = 73)

Figure 3. Place of living vs. Probiotic and Prebiotic Diet



(Key: Blue = On campus living, Orange = Off campus apartment, Gray = Off campus family home. N = 73)

Discussion

Knowledge

Further evaluating subsections of the study sample such as varying demographic groups such as sport, age, or place of living, the study found no ability to identify strong trends differentiating scores amongst groups within the ≤74 sample size.. Examples as seen in Table 10: Prebiotic and Probiotic Term vs. Age and Table 11: DRI of Fiber vs. Age,. Table 10 shows a 8.1-15.6% difference between ages 18 and 22+ and Table 11 shows a difference of 34.2% between ages 18 and 22. However both tables reveal no consistent trend of growth between each age and growth in correct answer which must be taken into account when determining the relationship reputability. Dissecting knowledge in comparison between place of living and sports teams was not evaluated due to the lack of balance in spread of data.

When considering previous research conducted, this study showed that in the past decade there may have been growth in knowledge or understanding of the benefits of prebiotic and probiotic foods in one's diet. In 2012 the Payahoo et al. study found that 59.7% of students with a background in health sciences identified the health effects of probiotics, whereas the questionnaire revealed that 39.2-86.5% of correct benefits were selected with an average number of 64%, showcasing a possible increase in understanding in recent years. Payahoo et al., also found that ability to define the term *probiotic* ranged from 43.9-83% (17) , while this study revealed the ability to define was 52.9% which is not higher nor lower than the range past studies have evaluated, showcasing no or minimal growth in knowledge.

Diet and health

A cross comparison was analyzed comparing place of living demographic and GI symptoms and diet. Figures 2 and 3 depict the cross comparison showing that there is a slight trend in that those living on campus are less likely to incorporate prebiotic and probiotic foods into their diet and more likely to experience GI disturbances, however this trend needs to be further evaluated with a larger sample size in order to show a more reliable trend. Figure 1 in the results displays supplementation use amongst the population possibly revealing that while 6-22.4% take prebiotic and probiotic supplements, 74.6% take other forms of supplements, possibly indicating student-athletes may prioritize other areas of their health over gut health.

Due to the amount of those that suffer from GI disturbance (60.8%) vs .those that have stated it has at some point prevented participation (19%). This may suggest the lack of uncertainty of significant the disturbance may be in terms of impacting competition, which may call for further investigation. Previous studies reported 30-70% of athletes experience some type of gastrointestinal disturbance, most relevant amongst endurance athletes and weight lifters (Coleman, 2019). Comparing the two studies, the survey supports previous studies conducted, showing a significant prevalence of GI disturbance amongst the athletic population.

Cross Comparison

The leading purpose of the study was to identify if student-athletes, at the NCAA Division One level, suffering from gastrointestinal disturbances, are influenced by an absence of knowledge and diet containing prebiotic and probiotic foods. The subsequent null hypothesis (H_0) states, GI symptoms are independent upon Var 1: knowledge scores and Var 2: diet. If failed to reject H_0 may have indicated an alternative hypothesis, (H_1) that GI symptoms are dependent upon Var 1: knowledge scores and Var 2: diet. After the Chi-Square Tests were

computed and revealed all three p-values over the value of 0.05, the study and subsequent results were unable to reject the null hypothesis, declaring gastrointestinal disturbances independent upon a student-athlete's knowledge and diet including prebiotic and probiotics sources.

Although this study was not able to reliably indicate the causes of GI disturbances in the student-athlete population, this study supported previous research of the absence of knowledge in prebiotic and probiotic terms, sources, and health benefits. This may indicate a need for intervention in the future. This study also coincided with past research concluding that GI disturbance continues to be prevalent within the athletic population, calling for attention and intervention as well. The gut microbiome may be an area of concern when evaluating an athlete who may be deficient in nutrient uptake and energy.

This study may be of use to future research and would benefit from analyzing results of a larger sample size, showing stronger, more reliable trends or relationships. Future research may also benefit from an individualized approach using an in-depth assessment into an athlete's diet and GI health. A thorough assessment may also reveal a more accurate depiction of level of knowledge in the topic of prebiotic and probiotic foods. In conclusion, further investigation needs to be conducted in order to reduce the prevalent statistics that were identified to be influencing the athletic community.

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