HIGH SCHOOL EDITION
Journal of Student Research
Volume 12 Issue 3 (2023)

The Correlation Between Three-mile Runners' Intake of Macronutrients and Their Performance

Anna Wakabayashi

Hoffman Estates High School

ABSTRACT

This paper examines the correlation between the female high school runner's nutrition intake and their performance in the three-mile race. In recent years, the rates of athletes experiencing body dissatisfaction and eating disorders are increasing due to high pressure to keep a "fit body", giving them a higher chance of getting injuries. Incorporating past experiments, graphs, and surveys, this study demonstrates that the runners are likely to run if their macronutrient intake reaches a certain balance, and runners with a balanced meal are capable of running longer distances with less injury than ones with an unbalanced meal. The research was done to identify the most effective and beneficial meal plan for athletes, specifically cross country runners. Its results are particularly evident in the quantitative-based graph created from survey responses, which compared the runners' intake of macronutrients and their running time.

Literature review

In recent years, especially with the major development of the media, our generation has been exposed to influencers with what is known as "great style" or "ideal body type", more than ever. With this, the topic of body image has become very widespread. A study done by Ipsos, an independent market research company managed by research professionals, found that in 2018, 79% of Americans experienced dissatisfaction or a feeling of unhappiness concerning their body image (Ipsos, 2018). When it comes to dieting or losing weight, one of the most common ways the media or internet would suggest is to cut down calories or to increase aerobic exercises, which mainly include walking and running. Contradictorily, an experiment performed on college athletes by the National Eating Disorders Association has discovered that athletes have a higher chance of developing eating disorders. They found that women athletes have a total of 93% chance of developing either anorexia or bulimia nervosa, and men have a 48% chance of developing either type of eating disorder (NEDA, 2019).

With insufficient amounts of calories and an increase in the amount of exercise, individuals can develop serious injuries, most commonly fragility fractures (Smith, 2013). A fragility fracture can be defined as a "fracture resulting from a fall from standing height or less" (Sorich, 2021). This injury can severely damage the hip, spine, wrist, and other jointed bones within the body. Because these injuries are caused by weakened muscle and bone, active individuals that lose significant amounts of muscle mass due to restrictive diet or nutrition deficiency can easily be diagnosed with this injury (Miller, 2022). Another common illness caused by nutrition deficiency is anemia. Anemia is a very common disease, having more than 3 million cases per year in the United States. It is caused by a deficiency in important nutrients, such as vitamin B12 and iron. The symptoms include individuals easily feeling weak or tired, lightheadedness, and shortness of breath (Mayo Clinic, 2022). This disease is not specifically common for athletes, but with the symptoms, it will take time away from doing any activities.

In addition, these injuries are not uncommon among professional athletes either. For example, in the magazine article Runner's World, Deena Kastor, an American long-distance runner who was an Olympic medalist in 2004 opened up about her suffering during the Olympics in Beijing. She explained how, even though she had a good amount of calcium in her bloodstream, due to a lack of vitamin 1, her body was prevented from utilizing it. This caused her right foot to break and prevented her from completing her race in the Olympics (ASP, 2009). Another professional

athlete who suffered a similar case is a well-known soccer player, Neymar Júnior. He is a Brazilian professional football player, one of the highest-paid players in the world, and a two-time World Cup participant. In August 2013, Barcelona (Neymar's previous soccer club) released a statement that he had been diagnosed with anemia. Despite Neymar's decision to continue playing football and insisting that there are no issues, his father has opened up his concern to TV Globo, a Brazilian television network, that "the physical tiredness he had is not normal and quite worrying". He continued and explained, "he almost has no fat to lose, and losing that muscle mass is troubling". With the combination of lacking important nutrients in his body such as vitamins and irons, and extreme training at Barcelona, it has been reported that he has lost 7 kilograms since he first was diagnosed (Football Espana, 2013).

While these injuries remain very common, there has been a lot of research done regarding the topic of body dissatisfaction and the diets of athletes (Swami, 2009). Some of the research includes researchers talking about how the media or influencers affect teenagers, causing them to feel insecure about themselves and what types of food to eat before a race or a game, to give the best performance. Although there were broad conclusions made by researchers, there is a gap that exists within the research, which is not having definite conclusions as to how meals consumed by an individual have a direct relation to their performance, especially with restrictive diets. To improve the existing research, this research will be focused on finding how a female runner's meal affects their performance, specifically, the meal consumed before the race. The reason for choosing running as a sport was because running seemed to be the most stereotypical aerobic sport, and it is the core of many other sports, such as football. Additionally, the decision to specify the study of female athletes is because women tend to have a higher rate of developing eating disorders and injuries due to weaker bones, and the solution to this is sought more urgently. The outcome of this topic is intended to develop a better understanding of athletes' diets, help athletes improve their performance without restrictive diets, develop better relationships with food and avoid unnecessary injuries.

Hypothesis

The initial hypothesis to the question, "How do high school female 3-mile runners' consumption of nutrition affect their running performance?", was that the more balanced the runner's meals are, the better performance they will have. In other words, the less lenient toward one specific group of nutrients their diets are, they would likely run faster in their race.

Although it has been acknowledged that the daily need for food consumption varies by the individual's age, weight, and activeness, the appropriate diet for teenage female athletes recommended by Rebecca L. Carl, a Sports Medicine Associate Professor of Pediatrics is as follows:

- 2000 to 3500 calories
- Carbohydrates (55 to 65%)
- Protein (15 to 20%)
- Fat (20 to 30%)

Additionally, it has been stated by the Cleveland Clinic that 1 gram of each carbohydrate and protein provides 4 calories, and 1 gram of fat provides 4 calories (Cleveland Clinic, 2019). Hypothetically, if each runner's consumption of calories per day was 2000 calories, and they have 3 main meals per day, then within each meal, their intake should be around 100 grams of carbohydrates (2000 calories× 60%÷4 calories/gram÷3 meals), around 25 grams of protein (2000 calories× 15%÷4 calories/gram÷3 meals), and around 14 grams of fat (2000 calories× 20%÷9 calories/gram÷3 meals). However, considering mid-day snack calories, and that dinner is likely to be a larger meal than any other meal, pre-race meals should contain around 50 grams of carbohydrate (2000 calories× 60%÷4 calories/gram÷5 meals), 12 grams of protein (2000 calories× 15%÷4 calories/gram÷5 meals), and 7 grams of fat (2000 calories× 20%÷9 calories/gram÷5 meals). Therefore, it was hypothesized that if the runner's consumption of macronutrients before the race is around the hypothesized amount, then they are likely to run faster. Additionally, this

hypothesis was developed based on the conclusion that was experimented with by Hellas Cena and Phillip C. Calder. They have found that healthier alternatives to Western diets reduce the risk of cardiovascular disease and cancer. Typical Western diets, such as pizzas and hamburgers are usually high in carbs and fat and not well balanced (Cena, 2020). From the data that a healthy meal/balanced meal led to better health conditions, it led me to believe that a balanced meal would lead to better running performance.

Methodology

To test my question, "How do meals consumed by female 3-mile runners affect their performance", I have decided to use a causal-comparative method. This is a quantitative methodology used to find the cause and effect relationship between two different variables (Qualtrics, 2023). One of the key components that I looked for when deciding on which method to use, was that it must be measured quantitatively. This was because quantitative tests allow me to study large sample sizes objectively and accurately. Since my experiment required analyzing large scales of performance data to find a relationship with food consumption, it was necessary to have a quantitative method. Another factor that was important to consider was that it must be a method that looked into trends and correlations. Because my research focused on finding how varying food choices result in better or worse performance, the methodology needed to test the direct relationship between two contrasting variables. Therefore, it came to my understanding that the causal-comparative method is the best-fit methodology to use in my experiment.

After deciding on the methodology, my next step was to define the independent and dependent variables. Firstly, the independent variable, a variable that is not affected by another variable, would be the food consumption by the runners. To make the experiment more precise and accurate, I have decided to specify the "food consumption" as the total intake of carbohydrate, protein, and fat per day. I have chosen these three nutrient types because they are the three elements of macronutrients. According to the British Heart Foundation, macronutrients are nutrients human needs in big quantities for us to be provided with energy (Silver, 2021). As for the dependent variable, a variable that is being measured throughout the experiment, was the performance of the runners. I have chosen to measure the performance by asking the runners about their race times from the previous season.

To collect the data on the number of macronutrients and runners' race times, I have decided to create a questionnaire/ survey that was distributed to high schools in the northwest suburbs of Chicago with girls' cross country teams. The survey included the following questions:

1. Name
2. Injuries they have experienced in the 2022 cross country season due to running
3. If they have a regular diet before or on the day of a running race
4. If yes to question 3, what do they eat the day before the running race (breakfast)
5. If yes to question 3, what do they eat the day of the running race
6. Their weekly mileage

The first question was asked so that I can gather their time from 3-mile races from previous seasons using *athletic.net*. This is a global website that provides team and individual sports data from the past and current. The second question was asked because my research is intended to decrease discomfort in eating and injuries due to malnutrition. The response to this question will help me find the possible correlation between nutrition and injuries. The following three questions were asked to find independent variables for my data. Lastly, I asked the runners for weekly mileage. I found this question to play a major role in my research, because no matter how unbalanced their meal was, if they practiced a lot more than the people with a balanced meal, they were likely to have better performance (Fitzgerald, 2020). Therefore, this question led me to get rid of the outliers from the collected data.

Then, using the survey results on what type of meal they eat on the day of the meet (breakfast/ pre-meet meal), I found each runner's consumption of each macro in terms of grams. I have decided to exclude the response on

what the runners consumed the day before because the majority of the response was way too broad. However, in the question where it only asked for what they eat on the day of the race, where it only included breakfast and pre-run snacks, the responses were much more specific and detailed. Therefore, I have decided to only use the response to the second question. To find the macro value of meals they have on the day of the race, I used an app called MyFitnessPal, which is a health and fitness tracking mobile app, owned by famous sportswear company, Under Armour, and it allows the user to calculate their macros just by typing the name of food. I decided to use this app, because it gives verified values, meaning that the information has been validated and "accurately reflects from the product packaging" (MyFitnessPal, 2020).

Lastly, after macro calculation, I organized my data into Excel and created a graph. Originally, the plan was to organize the data into dot graphs and bar graphs, having a range of time in the x-axis and each macro value in the y-axis to see the correlation between two variables; however, due to the non-appearance of the direct correlation between running time and grams of carbohydrate, protein, or fat, I decided to use a different type of graph, to see possible correlation from a different perspective. The new graph I chose was a radar graph, also known as a spider graph or star chart. This graph is commonly used to compare variables and see the similarities and outliers from the base graph. To summarize all the data into a radar graph, the first thing I did was divide up the whole data into 3 groups by runners' speed. The first group of runners was numbered 1 to 7, and it consisted of the fastest runners out of all data. The second group numbered 8 to 14, and it consisted of mid-time runners. The last group was numbered 15 to 21, and it consisted of the slowest runners out of all three. Then, I took the average of each macro within the group I divided. After taking the average, I divided the value of each macro by the base values to convert it into percentages. As a base value, I am using the numbers that I hypothesized earlier (50g of carb, 12g protein, 7g of fat). These numbers represent a 1:1:1 ratio, and it is the value that is hypothesized to be most balanced and has the highest likelihood of running the fastest.

Result and Findings

Out of 12 schools that were contacted, 6 schools responded, and 52 runners' information was gathered. In response to running-related injuries in the 2022 cross country season, 18 people answered they have experienced 1 injury, 10 people experienced 2 injuries, 3 people experienced 3 injuries, 4 people experienced 4 injuries, 1 person experienced 5 injuries, and 16 people experienced no injuries throughout the season. For the question that asked whether they have a specific diet on the day before or the day of the meet, 51.9 percent of runners (27 people) said they have a regular diet the day of the race, and the remaining 48.1 percent of runners (25 people) answered they do not have a specific diet before the race. Then, the people that answered "yes", responded to the question with their specific food they have. The food included such things as cereal, porridge, oatmeal, peanut butter and jelly, fruits…etc. The question where it asked for the runners' weekly mileage was only asked for respondents who answered "yes" to the specific diet, and the answer varied greatly. 1 respondent answered that they run 11-15 miles per week, 3 respondents answered 16-20 miles per week, 5 respondents answered 21-25 miles per week, 7 respondents answered 26-30 miles per week, 7 respondents answered 31-35 per week, 3 respondents answered 36-40, and 1 respondent answered 41+ miles per week. Lastly, using the name given by survey respondents, the last three race results from the 2022 season were gathered using athletic.net. As a result, the runners' average time varies from 19:07:40 to 25:33:00. The graph below is a summary of the collected data after the excess of outlier data. It demonstrates the data of runners who answered "yes" to a specific diet.

Table 1: Summary of Responses

Name	3-mile time	3-mile time	3-mile time	Average	Carbohydrate (g)	Fat (g)	Protein (g)	Injury	Weekly mileage
Margaretha Grabske	19:06	18:52	19:25	19:07:40	25.00	5.00	1.00	0	31-35
Ruth Hall	19:17	18:55	19:28	19:13:20	24.00	1.50	3.00	1	36-40
Tara O'Sul-livan	20:29	20:16	18:56	19:53:40	85.60	10.00	16.00	2	31-35
Fatima Sid-diqui	19:52	19:54	20:17	20:01:00	55.80	6.60	12.00	2	31-35
Katelyn Whitcomb	20:27	19:18	20:23	20:02:40	58.60	9.60	14.70	2	21-25
Jpia Sodimu	19:52	20:11	20:18	20:07:00	51.70	8.90	16.70	1	26-30
Brooke Donnelly	20:39	19:35	20:17	20:10:20	56.30	30.30	19.10	0	26-30
Milana Pisto	20:23	20:03	20:18	20:14:40	35.00	16.60	9.70	1	26-30
Lucy Scales	20:20	20:27	20:16	20:21:00	68.00	13.50	9.50	0	16-20
Lizzie Waltz	21:10	19:49	20:47	20:35	27	0.4	1.3	0	26-30
Emma Somenek	20:54	21:04	21:00	20:59:20	20.00	1.00	4.00	1	26-30
Julia Rakoczy	21:30	20:48	20:53	21:03:40	67.80	6.60	12.00	1	36-40
Claudia Kowalczyk	21:23	21:49		21:36	42	21	11	0	31-35
Charlotte Galer	22:29	21:17	21:15	21:40:20	75.80	6.80	17.00	1	26-30
Jazmyn George	22:15	21:25		21:50:00	110.00	4.90	16.30	4	31-35
Madeline Rakoci	23:18:00	21:31	22:01	22:16:40	63.20	17.20	17.10	1	21-25
Maddie Reid	22:59	23:25	23:48	23:24:00	65.60	21.20	13.60	1	21-25
Lenna Szczesniak	23:57	23:13	24:56:00	24:02:00	65.00	5.00	9.40	1	11 15
Isabel Ciesla	24:56:00			24:56:00	101.6	12.5	20	2	31-35
Triya Patel	25:52:00	24:44:00	25:14:00	25:16:40	28.80	5.90	6.40	2	16-20
Mia Wikar	25:46:00	25:21:00	25:32:00	25:33:00	67.60	17.60	11.90	3	16-20

By comparing the average percentage between runners' consumption of each macronutrient to the base values (hypothesized value), it resulted that the top 7 runners consume 102% of carbohydrates, 147% of fat, and 98% of protein of the recommended value, which is 100% for all macro elements (Table 3). In contrast, the runners that rank 8th to 14th consume an average of 96% of carbohydrates, 134% of fat, and 77% of protein. Lastly, the last 15th to 21st runners consumed 143% of carbohydrates, 172% of fat, and 113% of protein. The equation is shown in Table 3.

Discussion and Analysis

From the collected data, three conclusions could be drawn that satisfied the gap in the research. The research question was asked to develop a better understanding of runners' diets, specifically for female runners, so it can help combat harmful relationships with food, and prevent unnecessary injuries while improving performance.

Table 2: Average intake on macronutrients within 3 groups

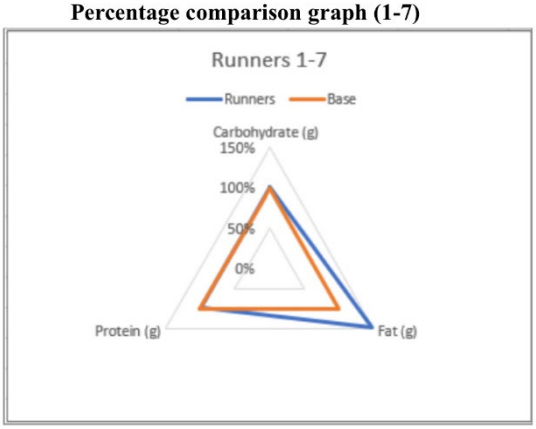
	Carbohydrate (g)	Fat (g)	Protein (g)
1	25.00	5.00	1.00
2	24.00	1.50	3.00
3	85.60	10.00	16.00
4	55.80	6.60	12.00
5	58.60	9.60	14.70
6	51.70	8.90	16.70
7	56.30	30.30	19.10
AVERAGE	51.00	10.27	11.79
8	35.00	16.60	9.70
9	68.00	13.50	9.50
10	27	0.4	1.3
11	20.00	1.00	4.00
12	67.80	6.60	12.00
13	42	21	11
14	75.80	6.80	17.00
AVERAGE	47.94	9.41	9.21
15	110.00	4.90	16.30
16	63.20	17.20	17.10
17	65.60	21.20	13.60
18	65.00	5.00	9.40
19	101.6	12.5	20
20	28.80	5.90	6.40
21	67.60	17.60	11.90
AVERAGE	71.69	12.04	13.53

Table 3: Macronutrients in percentages

	Runners (1-7)	**Base**
Carbohydrate (g)	(51/50) 102%	100%
Fat (g)	(10.27/7) 147%	100%
Protein (g)	(11.79/12) 98%	100%
	Runners (8-14)	**Base**
Carbohydrate (g)	(47.94/50) 96%	100%
Fat (g)	(9.41/7) 134%	100%
Protein (g)	(9.21/12) 77%	100%
	Runners (15-21)	**Base**
Carbohydrate (g)	(71.69/50) 143%	100%
Fat (g)	(12.04/7) 172%	100%
Protein (g)	(13.53/12) 113%	100%

Firstly, with the data that compared hypothesized value with the average macro value, the following statement can be concluded: if the runners' consumption of each carbohydrate, protein, and fat is similar to the hypothesized value, which is 50 grams of carbohydrate, 7 grams of fat and 12 grams protein, they are likely to run faster. To visualize the comparison, the radar graph is shown below. In all three graphs, the orange line demonstrates the base value, which is why the triangle is a 1:1:1 ratio. The blue line demonstrates the average percentage value of each macro calculated within the group.

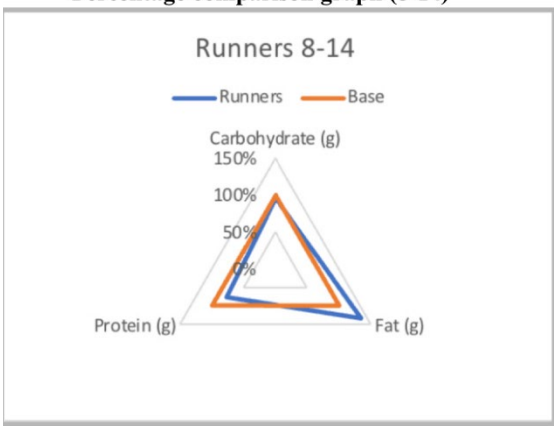
Percentage comparison graph (1-7)



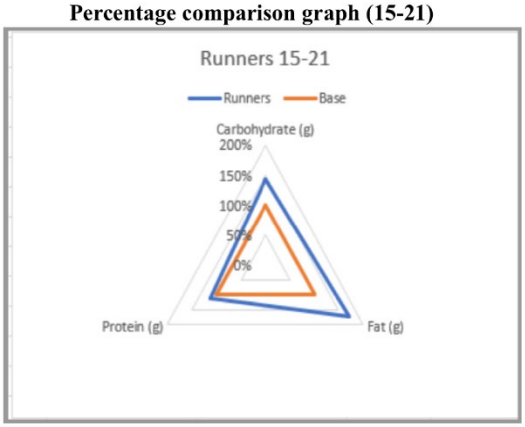
In the graph labeled Runners 1-7, the lines compare the data of the top 7 fastest runners' average consumption of each carbohydrate, fat, and protein to the value that is hypothesized to have the most benefit to running fast. Looking at the top of the triangle, which compares the percentage of carbohydrates, the base value of carbohydrates and the top 7 runners' average value only differ by 2%, showing that the runners' average consumption only goes 2% above the base value. Similarly, by comparing the percentage of protein from the base value to collected data, it only differs by 2% as well. However, in this specific section of macro, the runners' consumption average is lacking 2% from the base data. Lastly, looking at the section labeled fat, it is clearly shown that these runners consume much more fat than the base value. They go over by 47%. To summarize this graph, the top 7 runners' consumption of carbohydrates and protein is very close to what is hypothesized to be most beneficial to running fast, but their intake of fat is much greater than the hypothesized value.

Moving onto the next graph, in the graph labeled Runners 8-14, the lines compare the base macro value to the macro data of runners who ran mid-time, meaning the data of the groups that ran slower than the first group of runners, but faster than the third group of runners. When comparing the carbohydrate section, this group consumed an average of 96% of the base value. What this shows is that their intake of carbohydrates is lacking by 4% from what they should have to run fast. Similarly, their intake of protein is lacking as well. While the base value is represented as 100%, this group of runners' average intake is only 77%, lacking 23%. However, similar to the data of the first group, their intake of fat is greater than the base value. Their intake of protein is 134% of the base, consuming 34% more. In summary, the mid-time runners' consumption of both carbohydrates and protein is lacking, especially protein, by a significant amount, and the intake of fat is higher than what is recommended. Compared with the first group, the overall triangle is much more unproportioned in the second group, due to a greater difference in the average of each carbohydrate and protein intake to the base value.

Percentage comparison graph (8-14)



Percentage comparison graph (15-21)



In the last graph, labeled Runners15-21, the lines compare the base macro value to the macro data of the runners who ran the slowest within the collected data. In this group, the average consumption of carbohydrates was 143% of the base data, exceeding 43%. Additionally, in both protein and fat sections, this group consumed much greater amounts than the base value, having 113% and 172%, respectively. In summary, this group of runners' intakes on every element of macro exceeded by a great amount. Compared to the other two groups that had faster average time, this group's graph shows they had significant differences with the base value to their macro data, and this group is the only group that exceeds the base value in all categories of the macro.

Therefore, the data can confirm the statement: the group's average running time decreases as their intake of carbohydrates, fat, and protein gets closer to the base value, 50 grams of carbohydrate, 7 grams of fat, and 12 grams

of protein. This statement helps fill the gap because it adds new information to better understand female runners' diets, and this information can be used to confirm that runners do not have to overeat or undereat to give the best performance.

Table 4: Injuries occurred vs Weekly mileage

	Injury	Weekly mileage
1	0	31-35
2	1	36-40
3	2	31-35
4	2	31-35
5	2	21-25
6	1	26-30
7	0	26-30
8	1	26-30
9	0	16-20
10	0	26-30
11	1	26-30
12	1	36-40
13	0	31-35
14	1	26-30
15	4	31-35
16	1	21-25
17	1	21-25
18	1	11 15
19	2	31-35
20	2	16-20
21	3	16-20

Using this conclusion, there is another statement that could be made: there is only a minor relationship between food consumption, injury, and weekly mileage. The table on the right is the colored version of Table 1, in the previous section. It is in order from fastest to slowest, top to bottom. The rows highlighted in colors differ by their mileage per week. Blue is 36 to 40, red is 31 to 35, green is 26 to 30, cream is 21 to 25, gray is 16-20, and yellow is 11 to 15. Previously, it was concluded that the 7 runners on top had the most balanced meal, the bottom 7 had an unbalanced meal, and the middle 7 fell in between. However, comparing the number of injuries among the runners with similar running mileage per week, the number varies whether the runner is in the category of top 7 with a balanced meal or bottom 7 with a not very balanced meal. For example, when looking at the injury count of runners who run 31 to 35 miles per week, in rows 1 through 7, there is one runner who had 0 injuries throughout the season, and there are two runners that had 2 injuries. Then, in rows 8 through 14, there is one runner that runs 31 to 35 miles per week, and she had 0 injuries throughout the season. Lastly, in rows 15 to 21, a runner who ran the same distance per week had 2 injuries. This means that this runner, who had a non-balanced meal, experienced the same number of injuries as

a runner who had a very balanced meal. From this instance, it can be summarized that no matter if they are running the same distance, the balance of the meal does not affect their performance.

However, from different perspectives, other conclusions could be drawn. In rows 1 through 11, which is the top half of the whole data, their mileage per week is greater than what most of the bottom half of the runners run per week. However, the data suggests that the bottom half of runners experienced more injuries than the top half. In other words, the runners in the bottom half were running much less distance per week, but they experienced more injuries. So, with this perspective, it can be concluded that runners with balanced meals are more capable of running longer distances with fewer injuries. By changing the section of data to compare, two completely different conclusions were able to be drawn from the same data. This statement fills the gap in the sports industry because the data confirms that balance in meals is the key to fewer injuries.

Limitations and Future Research

Throughout the research, several limitations prevented the research to be most accurate. Firstly, the sample size. Out of 12 schools that were contacted, only half of the schools participated in the survey. Although it was enough to find a correlation between the runners' diet and their running performance, the outcome might have been different if the sample size was greater. Secondly, the accuracy of the data. In the calculation to find the base value in the hypothesis, 2,000 calories were used as what female runners consume per day because it was given that it is the average calorie consumed by teenagers. However, the calories consumed differ by people's weight, and height, and especially because the surveys were distributed to all cross country runners in high school, the range in ages was big, meaning the height and weight difference could range big as well. In addition, the accuracy of the app played a role in the possible inaccuracy of the data. In the survey response, the respondents put what they ate, but no specific brand of the food. Although all the macros used in the data from the MyFitnessPal app were verified values, the data would vary quite a bit with different brands or if it was homemade.

Considering these given limitations, some adjustments could be made in future research. The first is to get a bigger sample size. That way, it will be possible to close the range of calories calculation. For example, if the data of the runners' height and weight can be collected, then the researcher can perform the same experiment using the most fitted calorie value for each grade in high school. The second is to get a specific brand and serving size. This will help greatly in getting more accurate data.

In the future, with the conclusions this research led to, it will be interesting to compare if it also applies to male runners or other sports. Additionally, instead of just researching the meal they eat on the day of the race, performing the same experiment with their daily diet would solve so much more unknown in the field of diet and sport. Due to too broad of the responses, the data that asked for what they eat on the day before the race was not able to be used. So, I had to assume they have similar meal balances throughout the season, in the part where it was researching the correlation between injuries and weekly mileage. However, if it becomes possible to have a specific response to what they eat daily, it will be very interesting to see if it will have the same results or trend.

Conclusion

This research aimed to identify the most effective and beneficial meal plan for female high school cross country runners. Based on a quantitative analysis of runners' macronutrients values and their performance from the previous season, the following statement can be concluded:

- The runners are likely to run fast if their macronutrient intake is balanced, and close to the value of 50 grams of carbohydrate, 7 grams of fat, and 12 grams of protein.
- Runners with a balanced meal can run longer distances with less injury than ones with an unbalanced meal.

Going back to the introductory paragraph informing body dissatisfaction among teenage athletes, it was informed that athletes are feeling insecure about what food to eat, due to insufficient research in the female sports industry. It is hoped that by this research filling the gap of the unknown, it will ease the number of injuries due to malnutrition. However, as stated earlier, many factors could have been changed for better accuracy, and there are many new questions that are established from this research. Therefore, it will be interesting to see what future research will hold.

References

ACL Injuries and Female Athletes | Encyclopedia.com. (n.d.). https://www.encyclopedia.com/sports/sports-fitness-recreation-and-leisure-magazines/acl-injuries-and-female-athletes

Anemia - Symptoms and causes - Mayo Clinic. (2022, February 11). Mayo Clinic. https://www.mayoclinic.org/diseases-conditions/anemia/symptoms-causes/syc-20351360#:~:text=Anemia%20is%20a%20condition%20in%20which%20you%20lack,term%20and%20can%20range%20from%20mild%20to%20severe.

Asp, K. (2009, December 9). Running on D. *Runner's World*. https://www.runnersworld.com/nutrition-weight-loss/a20850590/running-on-vitamin-d/

Athletic.net. (n.d.). *Track & Field and Cross Country Statistics*. https://www.athletic.net/

Causal Research: Definition, Examples and How to Use it - Qualtrics. (2023, March 22). Qualtrics. https://www.qualtrics.com/experience-management/research/causal-research/

Cena, H., & Calder, P. C. (2020). Defining a Healthy Diet: Evidence for the Role of Contemporary Dietary Patterns in Health and Disease. *Nutrients*, *12*(2), 334. https://doi.org/10.3390/nu12020334

Eurosport. (2013, August 5). Neymar's anemia is worrying - father. *Eurosport*. https://www.eurosport.com/football/la-liga/2011-2012/neymar-s-anemia-is-worrying-father_sto3871335/story.shtml

Fat and Calories: The Difference & Recommended Intake. (n.d.). Cleveland Clinic. https://my.clevelandclinic.org/health/articles/4182-fat-and-calories#:~:text=A%20gram%20of%20fat%20has%20about%209%20calories%2C,of%20carbohydrate%20or%20protein%20has%20about%204%20calories.

Fitzgerald, J. (2020). 9 Reasons You're Running Slow (and how to fix them to get faster). *Strength Running*. https://strengthrunning.com/2014/07/9-reasons-youre-running-slow-and-how-to-fix-them-to-get-faster/#:~:text=Running%20long%20builds%20endurance%2C%20helps%20make%20faster%20paces,fitness%20declines%20and%20faster%20speeds%20seem%20more%20difficult.

Guides. (n.d.). The New York Times. https://www.nytimes.com/guides/well/healthy-eating-for-runners.

Ipsos. (2018, February 13). *Most Americans Experience Feeling Dissatisfied with How Their Body Looks from Time to Time, Including Nearly Two in Five Who Feel This Way Whenever They Look in the Mirror* (I. Ipsos, Ed.) [Review of *Most Americans Experience Feeling Dissatisfied with How Their Body Looks from Time to Time, Including Nearly Two in Five Who Feel This Way Whenever They Look in the Mirror*]. https://www.ipsos.com/en-us/news-polls/most-americans-experience-feeling-dissatisfied-with-body-looks-from-time-to-time

Latter, P. (2022, August 25). Essential guide to long runs. Runner's World. https://www.runnersworld.com/uk/training/a774503/8-tips-for-successful-long-runs/

Maisie.Silver. (2021). Nutrition: What Are Macros? *Beckwith Health Club*. https://www.beckwithhealthclub.co.uk/nutrition-what-are-macros/#:~:text=As%20per%20the%20British%20Heart%20Foundation%2C%20%E2%80%9CMacronutrients%20are,energy%3A%20in%20other%20words%2C%20fat%2C%20protein%20and%20carbohydrate.%E2%80%9D

Miller, A., Davison, J., Reider, L., Wilken, J. M., Glass, N. A., Kirkpatrick, T. K., Headlee, C., Fitzpatrick, D., Owen, E. B., Marsh, J. H., Willey, M. C., & Grossmann, R. E. (2022). Significant Loss of Skeletal Muscle Mass Occurs After Femoral Fragility Fracture. *Current Developments in Nutrition*, *6*(Supplement_1), 750. https://doi.org/10.1093/cdn/nzac062.019

Ms, E. Q. (2021). Sports Nutrition for Endurance Exercise. Verywell Fit. *https://www.verywellfit.com/sports-nutrition-for-endurance-exercise-3120671*

MyFitnessPal | MyFitnessPal. (n.d.). https://www.myfitnesspal.com/

National Eating Disorders Association. (2019, April 18). *Athletes & Eating Disorders*. https://www.nationaleatingdisorders.org/athletes-eating-disorders

Nazni, P., & Vimala, S. (2010). Nutrition Knowledge, Attitude and Practice of College Sportsmen. Asian Journal of Sports Medicine, 1(2). https://doi.org/10.5812/asjsm.34866

Smith, J. T., Halim, K., Palms, D. A., Okike, K., Bluman, E. M., & Chiodo, C. P. (2013). Prevalence of Vitamin D Deficiency in Patients With Foot and Ankle Injuries. *Foot & Ankle International*, *35*(1), 8–13. https://doi.org/10.1177/1071100713509240

Swami, V., Steadman, L., & Tovée, M. J. (2009). A comparison of body size ideals, body dissatisfaction, and media influence between female track athletes, martial artists, and non-athletes. Psychology of Sport and Exercise, 10(6), 609–614. https://doi.org/10.1016/j.psychsport.2009.03.003

Weigh-Ins, Weight Gain & Rules for Teen Athletes: AAP Report Explained. (n.d.). HealthyChildren.org. https://www.healthychildren.org/English/healthy-living/sports/Pages/Weigh-Ins-Weight-Gain-Rules-for-Teen-Athletes.aspx

What does the check mark mean? (2020, July 8). MyFitnessPal Help. https://support.myfitnesspal.com/hc/en-us/articles/360032273292-What-does-the-check-mark-mean-#:~:text=When%20MyFitnessPal%20believes%20a%20food,information%20from%20the%20product%20packaging.