**MEMORANDUM**

TO: U.S. Cycling Team; Attn: Mr. Joe Trainor

FROM: Premiere Consulting

DATE: February 23, 2021

SUBJECT: The Effects of Chocolate on Cycling Speed

Per our initial meeting, Premiere Consulting has been asked by Mr. Trainor, on behalf of the U.S. Cycling Team, to investigate the answers to the following questions:

* How does the regular consumption of chocolate affect the total distance covered during an all-out sprint?
* Does the type of chocolate consumed matter?

The investigation and analysis of these inquiries will be based on the study which recently came to the attention of Mr. Trainor (R.K.; Brouner, J.; Spendiff, O. *Journal of the International Society of Sports Nutrition.* **2015** 12:47).

**BACKGROUND ON STUDY**

The purpose of the study was to investigate the effects of chocolate (both dark and white) on the performance of cyclists. Specifically, the outcome variables quantified included:

* Oxygen consumption (ml/kg/min)
* Heart rate (bpm)
* Blood lactate (BLa)
* Blood pressure (mmHg)
* All-out bicycle sprint performance (meters)

Our focus will solely be on this last outcome variable.

The experimental setup was a randomized crossover design. In a randomized crossover design, each subject is rotated through the various treatments; the order of the study treatments is completely random for each subject. One benefit of this type of design is that it eliminates factors that vary from individual to individual, thereby affecting the results. In other words, each subject in the study operates as their own control (a control serves as a type of baseline). Another benefit of a crossover study is that it can be completed with fewer subjects since each subject will undergo each treatment (the study on the cyclists involved 9 subjects).

**PRESENTATION AND INTERPRETATION OF RESULTS**

The table below summarizes the outcome of the study on bicycle sprint performance.

|  |  |  |  |
| --- | --- | --- | --- |
| **BICYCLE SPRINT PERFORMANCE** | | | |
|  | Baseline | White Chocolate | Dark Chocolate |
| Mean Distance (m) | 1367 | 1419 | 1606 |
| Standard Deviation (m) | 171 | 248 | 158 |

The baseline sprint distance was measured prior to the treatment phases, which consisted of a 2-week treatment with white chocolate and a 2-week treatment with dark chocolate. The sprint distance was measured again after each treatment phase. The mean distance of each scenario is reported in the table.

The shortest mean distance was under the baseline conditions, while the greatest mean distance was under the dark chocolate treatment. The mean distance traveled under the white chocolate treatment is slightly higher than the baseline conditions; also, note the white chocolate treatment reports highest standard deviation. Standard deviation is a measure of how much values from the dataset vary from the mean.

**Confidence Intervals**

What is a confidence interval? What the study is investigating is whether there is a statistically significant difference in the all-out sprint distance with chocolate vs. without chocolate. Furthermore, is there a difference in performance with dark chocolate vs. white chocolate?

Note from the table above the baseline mean distance traveled (1367 m) and the dark chocolate mean distance traveled (1606). Using these mean values, the difference in the mean distances is 239 m. Similarly, the difference in mean distance of white chocolate (1419) and dark chocolate (1606) is 187m. These mean distances fall at the center of the confidence interval.

|  |  |
| --- | --- |
| **95% Confidence Interval for the population**  **average change in total distance covered** | |
| Dark Chocolate over baseline | 165 m to 314 m |
| Dark Chocolate over white chocolate | 82 m to 292 m |

A 95% Confidence Interval means that if the study were to be conducted 100 times, the true value of the difference in means would be contained within the calculated interval 95 times. This can be said with a 95% Confidence Level. **NOTE: A Confidence Level refers to the level of confidence in the statistical procedure used to obtain the confidence interval. The “true value” refers to the value we would expect to see in the population of professional cyclists.**

**P-Values**

Statisticians use a hypothesis test to determine if the starting hypothesis, called the null hypothesis, is valid. During the hypothesis test, the p-value is calculated to aid in coming to a determination. **The p-value is a measure of the likelihood of seeing an observation given that the null hypothesis is true.** **In this case, our null hypothesis would be that there is no difference in the distance a cyclist can cover during the timed sprint whether chocolate is consumed or not.** Quantitatively, this would mean that there is no significant difference between the mean of the baseline distance and the mean of the treatment distances. The p-values for this study are reported below:

|  |  |  |
| --- | --- | --- |
|  | **White Chocolate (WC)** | **Dark Chocolate (DC)** |
| **p-value (compared to baseline)** | 0.319 | 0.001 |
| **p-value (compared to WC)** |  | 0.003 |

It is a common practice to set a threshold p-value of 0.05, commonly referred to as the *significance level*. In this case, any p-values below 0.05 allow the null hypothesis to be rejected. Now, looking at the p-value table, we note that the p-value of the white chocolate is 0.319; this is ABOVE the significance level, which means the null hypothesis can not be rejected. In other words, the p-value of white chocolate when compared to the baseline implies that there is not a statistically significant difference in the distance a cyclist can cover in the timed sprint after consuming white chocolate.

However, the p-value for dark chocolate when compared to the baseline is 0.001; this p-value IS below the significance level of 0.05, meaning the null hypothesis can be rejected; there is a statistically significant difference in the distance a cyclist can cover in the timed sprint after consuming dark chocolate.

The p-value in the second row compares dark chocolate to white chocolate. In other words, if we were to start with the null hypothesis that there is no difference in performance when consuming white chocolate versus dark chocolate, what is the likelihood that we would see the difference of the mean distance covered for dark chocolate versus white chocolate (the difference in mean distance is 1606m – 1419m = 187m). The likelihood, according to the reported p-value, would be 0.003. This is below the significance level; therefore, the null hypothesis is rejected.

**CONCLUSIONS AND RECOMMENDATION**

Based on our study, we estimate with 95% confidence that a cyclist who consumes dark chocolate (1) is able travel between 165 m to 314 m further in the timed all-out sprint, compared to not consuming any chocolate at all; and (2) is able to travel 82 m to 292 m further in the timed all-out sprint, compared to consuming white chocolate.

There was no significant gain in distance by consuming white chocolate.

**Based on these conclusions, we recommend starting the U.S. Cycling Team on a regimen of dark chocolate in order to increase the distance traveled during the timed all-out sprint.**