The Short-Term Effects of Alcoholic Consumption on Athletic Abilities

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Stats 101B: Introduction to Design and Analysis of Experiment, Lecture 2
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Introduction

Our research investigates the immediate impact of alcohol consumption on arm strength, specifically the ability to perform arm curls. The motivation for this study stems from the high prevalence of alcohol consumption among college students in the United States, with 49.3% of full-time students aged 18 to 22 reporting alcohol use in the past month, and 27.4% engaging in binge drinking, according to the 2021 National Survey on Drug Use and Health (NIAAA, 2024). While there exists literature on the immediate detrimental effects of alcohol on judgment and coordination, as well as long term effects on liver health, our research aims to explore its immediate effects on athletic abilities, particularly in relation to arm curl strength. Our study used a Randomized Complete Block Design (RCBD) to ensure reliable results, and account for nuisance factors such as Age, Gender and Replicates. Participants underwent baseline arm curl strength tests, followed by the intake of three shots of Tequila (90 ml total), and subsequent re-testing of arm curl strength to measure changes in performance. We hypothesized that arm curl strength would decrease due to alcohol consumption, however, the study shows that there is no significant relationship between arm curl strength and immediate alcohol consumption. In the sections that follow, we further discuss the methods of data collection, detailed analysis, as well as conclusions.

Design of Experiment

Choice of Experimental Design

We chose an RCBD due to us having one response factor and two nuisance factors, so we chose it for its flexibility. Since we are measuring arm curl strength as a response to alcohol consumption, we decided to block our data according to age and gender (different ages and different genders tend to respond to alcohol differently and have naturally different arm strengths). After further consideration, we decided to increase our sample size by adding another replicate to our data to make our conclusion more reliable.

Data Collection

Age	Gender	Difference	BAC_D	Replicate
2	1	0	1	1
1	0	1	3	1
1	0	-2	2	1
2	1	1	3	1
1	0	-3	1	1
2	1	6	2	1
1	1	-2	1	1
3	1	1	3	1
3	1	1	2	1
3	0	-3	3	1
1	1	0	3	1
3	1	4	1	1
1	0	0	1	2
3	1	2	3	2
1	1	1	3	2
1	0	3	3	2
1	0	-1	2	2
1	1	2	2	1
2	0	2	1	1
2	0	1	2	1
2	0	7	3	1
1	1	-2	1	2
3	1	-1	1	2
1	1	-2	2	2
2	1	3	1	2

We used a random number generator to first sample 1 of the 3 islands. Then, another generator was used to sample one of the houses on the island. Finally, one more random number generator was used to sample the specific individual. If an individual refused consent, we sampled again from the same house. We sampled 120 observations, and subsampled the requisite 36 observations using random sampling. The participants' arm curl strength before and 10 minutes after consuming 90 ml of tequila was noted. The following data was collected about participants:

- Age (categorical variable, split into quantiles: 0.33. 0.67, 1)
- Gender (categorical variable, 0 for male and 1 for female)
- BAC_Dummy: Blood alcohol content measured 10 minutes after alcohol consumption (categorical variable, split into quantiles: 0.33. 0.67, 1). This is our *treatment variable.*
- Difference: Arm curl strength after alcohol consumption - Arm curl strength before alcohol consumption. *This is our response variable*

The experiment had 2 replicates to ensure sufficient data for inference to be made.This gives us a total of 36 data points. However, as per power calculations, we need closer to 4200 observations. This is a limitation of the experiment which we will elaborate further in the Discussion section.

Data Description

We choose the RCBD (Randomized Complete Block Design) for analysis of our data. We have two nuisance factors, one response and one treatment factor. The two nuisance factors are Gender and Age. We then changed the data to categorical values. For gender, if the participant is male, 1 is given, and if the participant is female, 2 is given. For age, based on our data, the minimum is 6 and the maximum is 94, so we set the data to be categorical value as 27 or less = 1,27 to 48 = 2,48 or more = 3 to block the data into three groups. In treatment (Blood.Alcohol.Level), BAC unit is g/dL, and min is 0.000, max is 0.018, so for change to the categorical value below 0.004 is 1, between 0.004 and 0.007 is 2, over 0.007 is 3. For Age and BAC factors, we chose the cutoffs based on the quantiles and medians of our data. Response is the difference between arm strength before and after 3 shots (30mL each) of tequila. Also, We decided to do 2 replicates in our design, which resulted in 36 observations.

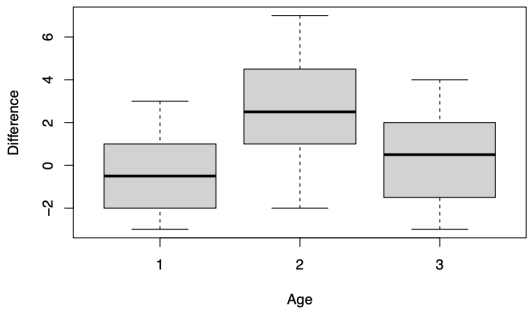
Results and Interpretation

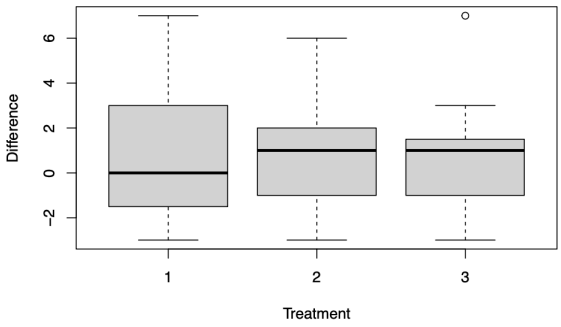
First, we created an ANOVA table to model the response variable Difference (arm curl strength after alcohol consumption - arm curl strength before alcohol consumption) with respect to the Treatment (Blood Alcohol Concentration) and Blocks for nuisance factors. Here, we are testing for the Null Hypothesis that the Treatment and Blocks do not have a significant effect on Difference, against the Alternative hypothesis that Treatment and Blocks do have a significant effect on Difference.

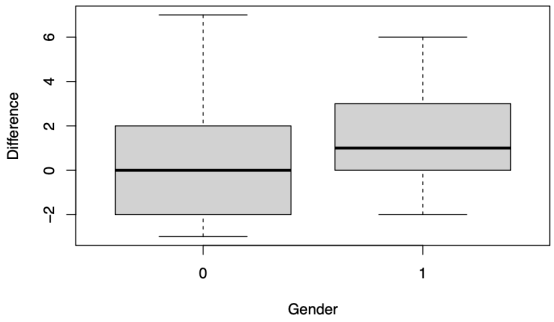
```
##             Df Sum Sq Mean Sq F value Pr(>F)
## Treatment    2   0.14   0.070   0.010  0.990
## Block       11  98.05   8.914   1.318  0.279
## Residuals   22 148.81   6.764
```

According to the table attached, the Treatment effect on Difference is not statistically significant. Moreover, the effect of Blocks on Difference has a smaller p-value, yet is not statistically significant at the 10% level. From this initial table, we do not have sufficient evidence to reject the null hypothesis and conclude Blood Alcohol Concentration has an effect on the response variable, which is Difference in arm curl strength. We can explore the relationship between the Response and each of the Blocking factors (Age and Gender) by using box plots, attached below.

Box Plots:

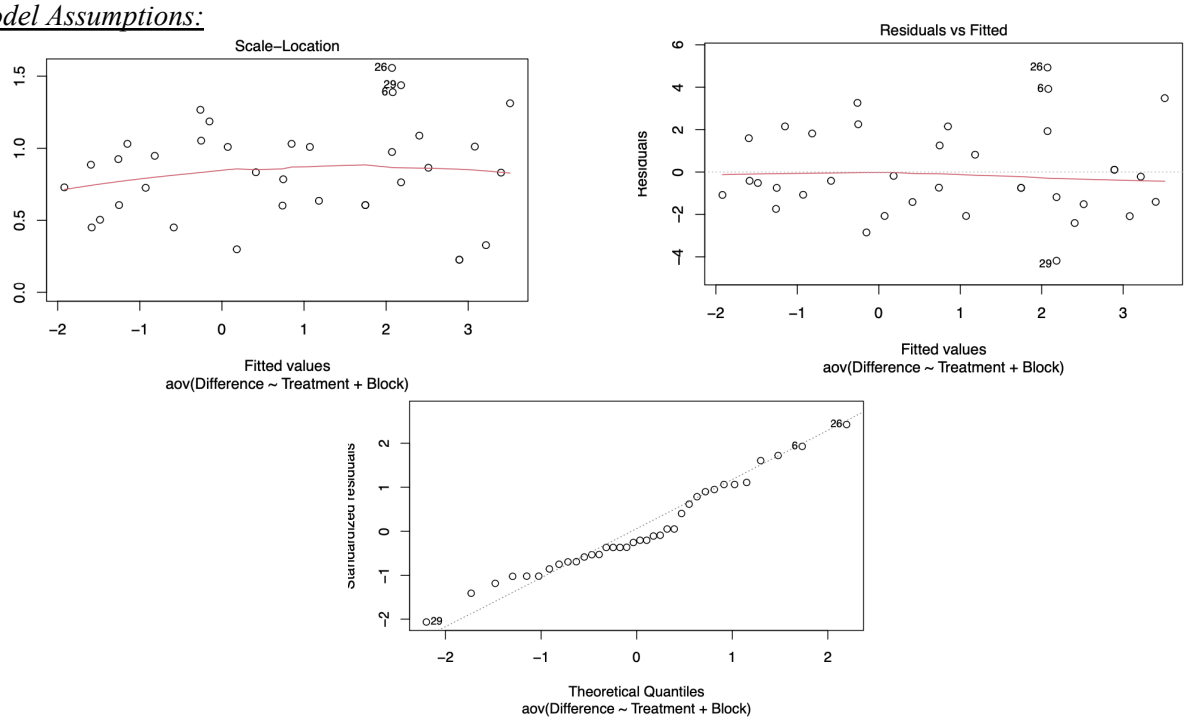






Preliminarily, it seems that blocking by Age and Gender was necessary. But as our ANOVA table showed, blocking in our experiment was unnecessary. As a result, we can interpret these box plots and their seeming significance as not accounting for the interaction between the blocking factors (Age and Gender).

Model Assumptions:



To ensure the results and hypothesis tests based on our model are reliable, it is important to check if we have satisfied the model assumptions. Using QQ Plots of theoretical quantiles against actual residuals, we can check if the normality assumption is satisfied. According to the normal QQ plots, most points do lie on the sloping line, and we can conclude that the model assumption of residual normality is satisfied. Moreover, we can check if the residuals are random and independently distributed using a Residual versus Fitted Values plot. From the scatterplot, residuals do seem like a random scatter and centered around a zero mean. We can conclude that model assumptions are satisfied.

T-Test:

We used a one sample t-test to test if the Difference in arm strength (our response variable) between before and after 90mL of tequila is significant.

```
##  One Sample t-test
##
## data:  df$Difference
## t = 1.8822, df = 35, p-value = 0.06815
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  -0.06550654  1.73217321
## sample estimates:
## mean of x
## 0.8333333
```

Our findings suggest that the difference is NOT significant, indicating that 3 shots (90 mL) of tequila does not impact curl arm strength when measured shortly before and after consumption. Although it is worth

noting that our test would be significant at the 10% level, however we were testing at the 5% level (our result is not significant).

Tukey's Test:

```
##            diff       lwr      upr     p adj
## 2-1 -0.14743590 -2.762829 2.467957 0.9890107
## 3-1 -0.09848485 -2.825617 2.628648 0.9954740
## 3-2  0.04895105 -2.627547 2.725449 0.9988370
```

We find that treatment 1 and 2 are the most different (moderate vs little). This is surprising since we expected 1 and 3 to have the largest difference. However, none of the differences are significant, which is concurrent with our findings from the ANOVA.

Discussion

Our study aimed to determine if alcohol consumption affects arm strength. The results suggest that consuming a moderate amount of alcohol (three shots of tequila) does not significantly impact arm strength immediately. In the real-world situation, our findings make sense to some extent. While moderate alcohol consumption might impair coordination, reaction time, and overall athletic performance, it may not significantly affect a simple task like arm curls.

Limitations

Although we did not find a significant relationship between alcohol consumption and immediate exercise, our study can be improved in certain key areas:

1. *Sample size:*

```
##
##  One Sample t-test
##
## data:  df$Difference
## t = 1.8822, df = 35, p-value = 0.06815
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
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## sample estimates:
## mean of x
## 0.8333333
```

```
     Balanced one-way analysis of variance power
calculation

              k = 3
              n = 12
              f = 0.07251777
      sig.level = 0.05
          power = 0.06323579

NOTE: n is number in each group
```

We see from the second image, that the current power of the experiment is quite low. To achieve a power of 0.8 (from the first image), we need 612 observations per group. Our current number of observations per group is 12.

2. *Interval between alcohol consumption and measurement varied:*
   Currently, we measured arm curl strength 10 minutes after alcohol consumption. However, this does not account for delayed reaction of alcohol with the body, which would affect BAC content.

Both the above limitations are a result of lack of resources for conducting the study.

Relation to Current Literature

Our study had certain limitations, such as a small sample size that could affect the generalizability of our results. Interestingly, real-life studies do not support our findings. For instance, a study by Shaw et al.[1] highlights a significant difference in athletic performance after alcohol consumption. However, it is important to note that Shaw's study focuses on next-day impacts, rather than immediate effects.

> **Methods:** On 2 occasions, 12 recreationally active individuals reported to the Applied Physiology Laboratory in the evening and ingested a beverage containing either 1.09 g ethanol·kg-1 fat-free body mass (ALC condition) or water (PLA condition). The following morning, they completed a hangover symptom questionnaire, vertical jumps, isometric midthigh pulls, biceps curls, and a constant-power cycle ergometer test to exhaustion. The responses from ALC and PLA were compared using paired-means t tests.
>
> **Results:** Time to exhaustion in the cycle ergometer tests was less (P = .03) in the ALC condition (181 [39] s vs 203 [34] s; -11%, Cohen d = 0.61). There was no difference in performance in vertical jump test, isometric midthigh pulls, and biceps curls tests between the ALC and PLA conditions.
>
> **Conclusions:** Previous-day alcohol consumption significantly reduces morning-after performance of severe-intensity exercise. Practitioners should educate their athletes, especially those whose events rely on anaerobic capacity and/or a rapid response of the aerobic pathways, of the adverse effect of previous-day alcohol consumption on performance.

References

Shaw AG, Chae S, Levitt DE, Nicholson JL, Vingren JL, Hill DW. Effect of Previous-Day Alcohol Ingestion on Muscle Function and Performance of Severe-Intensity Exercise. Int J Sports Physiol Perform. 2022 Jan 1;17(1):44-49. doi: 10.1123/ijspp.2020-0790. Epub 2021 Jul 5. PMID: 34225252

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National Institute of Alcohol Abuse and Alcoholism. 2024 Jan; https://www.niaaa.nih.gov/publications/brochures-and-fact-sheets/time-for-parents-discuss-risks-college-drinking#:~:text=Rates%20and%20Consequences%20of%20College,during%20the%20same%20time%20frame..

[1] Shaw AG, Chae S, Levitt DE, Nicholson JL, Vingren JL, Hill DW. Effect of Previous-Day Alcohol Ingestion on Muscle Function and Performance of Severe-Intensity Exercise. Int J Sports Physiol Perform. 2022 Jan 1;17(1):44-49. doi: 10.1123/ijspp.2020-0790. Epub 2021 Jul 5. PMID: 34225252.