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Portfolio Assignment 3

Study of Lower back pain and grip strength

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# Introduction

We are presented with two studies, first one is the study of severity of lower back pain in adult males working in Scottish manufacturing industry. The study captures severity of lower back pain for workers who do manual work and non-manual work. We need to identify if there is any dependency of severity of pain on type of work the workers are doing.

Second study, explores the data of grip strength of male rock climbers. It is believed that grip strength is of great importance in the sport of rock climbing. We will find out if the grip strength varies among various groups of people ranging from elite climbers to recreational climbers

# Lower back pain severity in adult Scottish male.

## Background:

A recent study of lower back pain in Scottish Industry looked at the effect of the type of work (i.e. manual or non-manual) on the severity of back pain over the previous 6 months. The sample was assumed to be representative of all adult males in the Scottish manufacturing industry.

## Questions:

Is the distribution of the severity categories of back pain different for manual and non-manual workers in the Scottish manufacturing industry?

If so, ‘where’ are there significant differences? For example, is the proportion of the population of manual workers who suffer severe back pain a significantly greater proportion than in the non-manual population?



From the above graph it is clear that there is a bigger proportion of Scottish adult males with **severe pain** who are into Manual work, and a smaller proportion of people with **No pain** in the Manual work type.

To confirm and formally compare the proportions of different pain types between two types of work we will carry out a chi-squared test of

H0: There is no significance difference between Manual and Non-Manual work type population proportion of each pain type.

HA: There is some difference between 2 sets of population proportions.

## Chi-Square Test for Association: Worksheet rows, Worksheet columns

### Rows: Worksheet rows   Columns: Worksheet columns

|  |  |  |  |
| --- | --- | --- | --- |
|  | Non-Manual | Manual | All |
|  |  |  |  |
| 1 | 508 | 224 | 732 |
|  | 376.0 | 356.0 |  |
|  | 46.37 | 48.97 |  |
|  |  |  |  |
| 2 | 583 | 407 | 990 |
|  | 508.5 | 481.5 |  |
|  | 10.92 | 11.53 |  |
|  |  |  |  |
| 3 | 192 | 584 | 776 |
|  | 398.6 | 377.4 |  |
|  | 107.05 | 113.05 |  |
|  |  |  |  |
| All | 1283 | 1215 | 2498 |

*Cell Contents  
      Count  
      Expected count  
      Contribution to Chi-square*

From the above statistics we can see that P-value of <0.001 is much less than 0.05 and hence there is a strong evidence against Null Hypothesis and we can reject the Null Hypothesis H0.

Thus, we can say that there is a significance difference in the population proportions of some pain types between Manual and Non-Manual work type groups

To identify which of the pain types have different proportions between the Manual and Non-Manual populations we need to perform a Two-sample interval estimate for the difference in population for each of the pain type separately.

## For severity - None

### Test and CI for Two Proportions

#### Method

|  |
| --- |
| p₁: proportion where Sample 1 = Event |
| p₂: proportion where Sample 2 = Event |
| Difference: p₁ - p₂ |

#### Descriptive Statistics

|  |  |  |  |
| --- | --- | --- | --- |
| Sample | N | Event | Sample p |
| Sample 1 | 1283 | 508 | 0.395947 |
| Sample 2 | 1215 | 224 | 0.184362 |

#### Estimation for Difference

|  |  |
| --- | --- |
| Difference | 95% CI for Difference |
| 0.211585 | (0.177066, 0.246104) |

*CI based on normal approximation*

#### Test

|  |  |
| --- | --- |
| Null hypothesis | H₀: p₁ - p₂ = 0 |
| Alternative hypothesis | H₁: p₁ - p₂ ≠ 0 |

|  |  |  |
| --- | --- | --- |
| Method | Z-Value | P-Value |
| Normal approximation | 12.01 | 0.000 |
| Fisher's exact |  | 0.000 |

From the above statistics it can be stated that there are between 17.7% and 24.61% more males with No back pain in Non-Manual work group than manual work group. Thus, doing manual work increase the chances of getting back pain.

## Severity – Modest

### Test and CI for Two Proportions

#### Method

|  |
| --- |
| p₁: proportion where Sample 1 = Event |
| p₂: proportion where Sample 2 = Event |
| Difference: p₁ - p₂ |

#### Descriptive Statistics

|  |  |  |  |
| --- | --- | --- | --- |
| Sample | N | Event | Sample p |
| Sample 1 | 1283 | 583 | 0.454404 |
| Sample 2 | 1215 | 407 | 0.334979 |

#### Estimation for Difference

|  |  |
| --- | --- |
| Difference | 95% CI for Difference |
| 0.119424 | (0.081390, 0.157459) |

*CI based on normal approximation*

#### Test

|  |  |
| --- | --- |
| Null hypothesis | H₀: p₁ - p₂ = 0 |
| Alternative hypothesis | H₁: p₁ - p₂ ≠ 0 |

|  |  |  |
| --- | --- | --- |
| Method | Z-Value | P-Value |
| Normal approximation | 6.15 | 0.000 |
| Fisher's exact |  | 0.000 |

From the above statistics it can be stated that there are between 8.13% and 15.74% more males with Moderate back pain in Non-Manual work group than manual work group. Thus, doing non-manual work increase the chances of getting a modest back pain.

## Severity – Severe

### Test and CI for Two Proportions

#### Method

|  |
| --- |
| p₁: proportion where Sample 1 = Event |
| p₂: proportion where Sample 2 = Event |
| Difference: p₁ - p₂ |

#### Descriptive Statistics

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sample | N |  | Event | Sample p |
| Sample 1 | 1283 |  | 192 | 0.149649 |
| Sample 2 | 1215 |  | 584 | 0.480658 |

#### Estimation for Difference

|  |  |
| --- | --- |
| Difference | 95% CI for Difference |
| -0.331009 | (-0.365218, -0.296800) |

*CI based on normal approximation*

#### Test

|  |  |
| --- | --- |
| Null hypothesis | H₀: p₁ - p₂ = 0 |
| Alternative hypothesis | H₁: p₁ - p₂ ≠ 0 |

|  |  |  |
| --- | --- | --- |
| Method | Z-Value | P-Value |
| Normal approximation | -18.96 | 0.000 |
| Fisher's exact |  | 0.000 |

From the above statistics it can be stated that there are between 29.68% and 36.52% less males with Severe back pain in Non-Manual work group than Manual work group. Thus, doing Non-Manual work decreases the chances of getting a severe back pain.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Severity | Non-Manual | Manual | Difference | 95% CI for difference. |
| None | 0.396 | 0.184 | 0.211 | (0.177 , 0.245) |
| Modest | 0.454 | 0.334 | 0.119 | (0.081 , 0.157) |
| Severe | 0.149 | 0.480 | -0.331 | (-0.365 , -0.296) |

From the above table it is clear that, 0 does not lie in any of the three confidence intervals for None, Modest and Severe pain severity and hence, we can say that there is a significance difference in population proportion in Non-Manual and Manual work groups for each of the severity of back pain in adult males in Scottish manufacturing industry.

Further, it can be stated that chances of Severe back pain reduce when doing Non-Manual type of work while the chances of No pain or moderate pain increases for Non-Manual type of work as compared to the Manual type of work. Hence, we can say that doing Manual increase the chances of getting back pain.

## Manual Check

H0: There is no significance difference between Manual and Non-Manual work type population proportion of each pain type.

HA: There is some difference between 2 sets of population proportions.

α = 0.05

No. of rows (R) = 3

No. of columns (C) = 2

Degree of freedom(df) = (R-1)(C-1)

= (3-1)(2-1)

= 2

Critical Value = 5.991

Chi Square x2

Calculating Expected Values using formulae

E =

|  |  |  |  |
| --- | --- | --- | --- |
| Severity | Non-Manual | Manual | Row Totals |
| None (Observed) | 508 | 224 | **732** |
| None (Expected) | ( | ( |
| Modest (Observed) | 583 | 407 | **990** |
| Modest (Expected) | ( | ( |
| Severe (Observed) | 192 | 584 | **776** |
| Severe (Expected) | ( | ( |
| Column Totals | **1283** | **1215** | **2498** |

x2 = ∑

=

= 337.89

From the above manual calculation, we can see that Chi Square x2 value (337.89) is greater than the critical value (5.991) hence, we can reject Null Hypothesis.

Thus, we can say that there is a significance difference in the population proportions of some pain types between Manual and Non-Manual work type groups

# Grip Strength of climbers

## Background:

In the sport of rock climbing, the steeper the rock face is, generally, the more difficult the climb is graded. It has been suggested that grip strength is of great importance in climbing.

## Aim:

A study was carried out to compare average grip strength of the dominant hand among three populations of male climbers (i.e. Elite, Recreational and non –climbers Controls).



From the above box plot we can say that there is huge difference in grip strength between Control and Elite groups and also Recreational and Elite groups as the box for elite groups does not overlap with the other two groups. And also, since the box for elite group is on right of the other groups we can say that they have higher grip strength

Box for Recreational and Control groups overlap highly and hence we can say that there is no significance difference between the two.

To confirm, the above observations we will perform further analysis using One-way ANOVA test.

## Descriptive Statistics: Strength

### Statistics

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variable | Group | N | N\* | Mean | SE Mean | StDev | Variance | Minimum | Q1 | Median |
| Strength | Control | 15 | 0 | 358.33 | 5.27 | 20.43 | 417.24 | 325.00 | 340.00 | 360.00 |
|  | Elite | 15 | 0 | 399.20 | 4.35 | 16.86 | 284.31 | 375.00 | 382.00 | 400.00 |
|  | Recreational | 15 | 0 | 351.00 | 6.18 | 23.92 | 572.14 | 320.00 | 330.00 | 345.00 |

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Group | Q3 | Maximum |
| Strength | Control | 375.00 | 390.00 |
|  | Elite | 415.00 | 425.00 |
|  | Recreational | 360.00 | 400.00 |

From the above statistics we can see that Mean and Median for the three groups are similar and hence the data is normalized which is a necessary condition to perform one-way ANOVA test.

We will perform the one-way ANOVA using the below NULL and Alternative hypothesis

H0: Population mean grip strength is same among the three groups

HA: Population mean grip strength is not same among the three groups

## One-way ANOVA: Strength versus Group

### Method

|  |  |
| --- | --- |
| Null hypothesis | All means are equal |
| Alternative hypothesis | Not all means are equal |
| Significance level | α = 0.05 |

*Equal variances were assumed for the analysis.*

### Factor Information

|  |  |  |
| --- | --- | --- |
| Factor | Levels | Values |
| Group | 3 | Control, Elite, Recreational |

### Analysis of Variance

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
| Group | 2 | 20236 | 10117.8 | 23.83 | 0.0000001 |
| Error | 42 | 17832 | 424.6 |  |  |
| Total | 44 | 38067 |  |  |  |

### Model Summary

|  |  |  |  |
| --- | --- | --- | --- |
| S | R-sq | R-sq(adj) | R-sq(pred) |
| 20.6050 | 53.16% | 50.93% | 46.23% |

### Means

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Group | N | Mean | StDev | 95% CI |
| Control | 15 | 358.33 | 20.43 | (347.60, 369.07) |
| Elite | 15 | 399.20 | 16.86 | (388.46, 409.94) |
| Recreational | 15 | 351.00 | 23.92 | (340.26, 361.74) |

*Pooled StDev = 20.6050*

### Interval Plot of Strength vs Group



From the above statistics we can see that P-value (<0.01) is much smaller than 0.05 and hence we can reject Null Hypothesis of population mean grip strength being equal among three groups. Hence, there are some differences in the mean grip strength among three groups. Also, the graph shows how the mean varies in three different groups. We can see that mean is highest for control group while it is lowest for Recreational group.

Now that we have established that there is a difference in mean grip strength among three different group, we will now find out which groups are significantly different using a multiple comparison procedure to generate a set of simultaneous intervals estimates for all the pairwise comparisons.

### Grouping Information Using the Tukey Method and 95% Confidence

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Group | N | Mean | Grouping | |
| Elite | 15 | 399.20 | A |  |
| Control | 15 | 358.33 |  | B |
| Recreational | 15 | 351.00 |  | B |

*Means that do not share a letter are significantly different.*

### Tukey Simultaneous Tests for Differences of Means

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Difference of Levels | Difference of Means | SE of Difference | 95% CI | T-Value | Adjusted P-Value |
| Elite - Control | 40.87 | 7.52 | (22.57, 59.17) | 5.43 | 0.000 |
| Recreational - Control | -7.33 | 7.52 | (-25.63, 10.97) | -0.97 | 0.597 |
| Recreational - Elite | -48.20 | 7.52 | (-66.50, -29.90) | -6.41 | 0.000 |

*Individual confidence level = 98.07%*



The first interval is for the Elite minus Control group and is 22.57 to 59.17 degrees of difference in grip strength between the two. The entire range is positive and hence the mean grip strength of elite group is significantly higher than the mean grip strength of Control group of climbers

The second interval is for the Recreational Minus Control group and is -25.63 to 10.97 degrees of difference between the two. The 0 lies between the interval and hence we can conclude that there is no significant difference between grip strength of two groups.

The third interval is for the Recreational Minus Elite group and is -66.50 to -29.90 degrees of difference in grip strength between the two. The entire range is negative and hence the mean grip strength of elite group is significantly higher than the mean grip strength of Recreational group of climbers.

This study provides evidence of a significant difference in grip strength of the three groups (P-value < 0.001). In general, Elite climbers have a significantly higher grip strength as compared to recreational and control group of climbers.

A better approach to check the normal distribution is to use a residual plot. It is the difference between observed and expected values for each observation



The above normal probability plot shows that the residuals follow a straight line except few outliers and hence data is normally distributed.



There is nothing in the graph to raise any concerns regarding the underlying model assumptions.

We see that residuals “fan out” from left to right rather than exhibiting a consistent spread around residual line (0 line). Thus, the plot suggests the error variances are not equal.

## Manual Check

H0: Population mean grip strength is same among the three groups

HA: Population mean grip strength is not same among the three groups

α = 0.05

Number of different sample **K** = 3

The sample size of group 1 **N1** = 15

Sum of values in group 1 **T1** = (320+330+330+330+340+340+340+345+350+350+360+360+370+400+400)

= 5265

The sample size of group 2 **N2** = 15

Sum of values in group 1 **T2** = (375+378+380+382+385+390+395+400+405+408+412+415+418+420+425)

= 5988

The sample size of group 3 **N3** = 15

Sum of values in group 1 **T3** = (325+330+335+340+345+350+355+360+365+368+372+375+380+385+390)

= 5375

Total sample size **N = N1 + N2+ N3**

= 15 + 15 + 15

= 45

Sum of all values in all samples **∑x = T1 + T2 + T3**

= 5265 + 5988 + 5375

= 16628

Sum of Squares of all values in all samples **∑ =** +(320)2+(330)2+(330)2+(330)2+(340)2+(340)2+(340)2+(345)2+(350)2+(350)2+(360)2+(360)2+(370)2+(400)2+(400)2+(375)2+(378)2+(380)2+(382)2+(385)2+(390)2+(395)2+(400)2+(405)2+(408)2+(412)2+(415)2+(418)2+(420)2+(425)2+(325)2+(330)2+(335)2+(340)2+(345)2+(350)2+(355)2+(360)2+(365)2+(368)2+(372)2+(375)2+(380)2+(385)2+(390)2

**= 6182298**

Degree of freedom Between **dfB = k-1** = 3-1 = 2

Degree of freedom Within **dfW = n-k** = 45-3 = 42

Total degree of freedom **dfT = dfB + dfW =** 42 + 2 = 44

Df = (2,42)

Critical Value = 3.22 (Table given in class does not have 42, it only has 40 for denominator so using the value that is slightly lower than value of 40 which is 3.23)

### Sum of Squares Between samples

**SSB = ( –**

= ( –

= (1848015 + 2390409.6 + 1926041.667) – 6144230.756

= 20235.51

### Sum of Squares Within Samples

**SSW = ∑ – (**

= 6182298 - (1848015 + 2390409.6 + 1926041.667)

= 17831.73

**SST = SSB + SSW**

= 20235.51 + 17831.73

= 38067.24

### Mean Square Between groups

**MSB =**

=

= 10117.75

### Mean Square Within groups

**MSW =**

=

= 424.56

### F Statistics

**F =**

**=**

= 23.83

### ANOVA Table

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Source of Variation | Degrees of Freedom | Sum of Squares | Mean Square | Value of the Test Statistic |
| Between  Within | 2  42 | 20235.51  17831.73 | 10117.75  424.56 | F = = 23.83 |
| Total | 44 | 38067.24 | 10542.32 |

Since the calculate value for F (23.83) is much greater than critical value (3.22) we will reject the Null Hypothesis. Hence, there are some differences in the mean grip strength among three groups

# Conclusion

From the above study we conclude that severity of back pain varies between Manual and Non- Manual workers. Manual workers tend to have a higher probability of getting a severe pain. And in general workers doing manual work are prone to lower back pain as compared with workers doing Non-manual work in the Scottish manufacturing industry.

The second study clearly shows that the grip strength of elite male rock climbers is very high as compared to recreational and control group of climbers. Thus, we can say that since elite climbers performs high grade climbs with steep rock faces a higher grip strength is developed and required among elite climbers.