Parametric Tests

Data Analysis Group A

Contents

1 Data Set Description

Dataset

- 14 variables including Age, Sex, BP, Max HR, Cholesterol, heart disease presence…etc…
- 270 rows of data
- The variables consist of a mix of numerical and categorical variables

2 Power and Effect Size

Reality:

Result of testing:	True	False
True		Type I error (alpha)
False	Type II error (beta)	

- To decrease Type I error, decrease the significance level.
- To decrease Type II error, increase the power (1-beta).

Power Analysis

- The calculation of power is usually done before any sample data have been collected.
- The precise estimation of the power may tell investigators how likely it is that a statistically significant difference will be detected based on a finite sample size under a true alternative hypothesis.
- If the power is too low, there is little chance of detecting a significant difference, and non-significant results are likely even if real differences truly exist.

Power Analysis

- Assume that we want to run a one-way ANOVA test for the independent variable chest pain type and the dependent variable Max HR.

Tests of Between-Subjects Effects

Dependent Variable: Max HR

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	14607.157[a]	3	4869.052	10.316	.000	.135	30.948	.998
Intercept	3600163.590	1	3600163.590	7627.689	.000	.975	7627.689	1.000
Chestpaintype	14607.157	3	4869.052	10.316	.000	.135	30.948	.998
Error	93925.247	199	471.986					
Total	4742573.000	203						
Corrected Total	108532.404	202						

a. R Squared = .135 (Adjusted R Squared = .122)

b. Computed using alpha = .05

Power Analysis

- Partial eta squared is a way to measure the effect size of different variables.
- With that sample size, and an effect size of 13.5%, there is a 99% chance of detecting a difference that is really there.

One Sample T-test 3

One Sample T-test

- One sample t-test compares a sample with the population
- For this analysis we will determine if there is a significant difference between the average cholesterol level of our sample and the average cholesterol level worldwide
- Average cholesterol level worldwide: 178 mg/dL

One Sample T-test

- **Null Hypothesis (H0):** There is no significant difference between the mean value of cholesterol in the population and the mean value of cholesterol in our sample
- **Alternate Hypothesis (H1):** There is a significant difference between the mean value of cholesterol in the population and the mean value of cholesterol in our sample

One Sample T-test

	Histograms	Box Plots	Q-Q Plots	P-P Plots	Skewness	Kurtosis	Shapio-Wilk	Kolmogorov-Smirnov	Anderson-Darling
Age	✓	✓	✓	✓	✓	✓	×	×	×
BP	✓	✓	✓	✓	×	×	×	×	×
Cholesterol	✓	✓	✓	✓	✓	✓	×	✓	×
Max HR	×	×	✓	✓	×	×	×	×	×
ST Depression	×	×	×	×	×	×	×	×	×

- From our previous presentation, cholesterol is approximately normal

One Sample T-test

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Cholesterol	253	248.76	51.406	3.232

One-Sample Test

	Test Value = 178						
			Significance			95% Confidence Interval of the Difference	
	t	df	One-Sided p	Two-Sided p	Mean Difference	Lower	Upper
Cholesterol	21.894	252	<.001	<.001	70.759	64.39	77.12

- Calculated t-value is greater than critical t-value (1.984) → accept H1 and reject H0
- P-value is less than 0.05 → accept H1 and reject H0
- No zero between lower and upper bounds → accept H1 and reject H0

One Sample T-test

- Based on the results we will accept the alternate hypothesis and reject the null hypothesis
- Conclusion: There is a significant difference between the mean cholesterol value of the population and the mean cholesterol value of our sample, our sample has a higher mean cholesterol with a mean difference of 70.76

4 Paired Samples T-test

Paired Samples T-test

- In a paired samples t-test we compare the same group at different points in time
- One example used in the lecture was: the effect of chemotherapy on cancer tumor thickness
- This had data of tumor thickness from the same group before and after the treatment
- Our data set does not have data for the same group at different points in time, so, we cannot perform a paired sample t-test on our data set

5 Unpaired Samples T-test

Unpaired Samples T-test

- The independent t-test is used to compare two different groups in order to recognise their characteristics.
- Determines whether there is a statistically significant difference between the means of two unrelated groups.
- To perform an independent t-test, you need an independent categorical variable with two levels/groups and a continuous dependent variable.
- It is important to use the same sample size for both groups to avoid different P-values.

Null and alternative hypotheses for the independent t-test

- The **null hypothesis** for the independent t-test is that the population means of the two unrelated groups are equal: H0: u1 = u2

- The **alternative hypothesis** is that the population means are not equal: H1: u1 ≠ u2

Independent t-test for blood pressure

Group Statistics

	Sex	N	Mean	Std. Deviation	Std. Error Mean
Normal_BP	0	77	130,3801	17,48387	1,99247
	1	77	125,7968	14,21238	1,61965

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
Normal_BP	Equal variances assumed	2,653	,105	1,785	152	,038	,076	4,58339	2,56773	-,48965	9,65643
	Equal variances not assumed			1,785	145,913	,038	,076	4,58339	2,56773	-,49135	9,65813

We accept H0, there is no significant difference between the mean BP of the two sexes.

Independent t-test for maximum heart rate

Group Statistics

	Sex	N	Mean	Std. Deviation	Std. Error Mean
Normal_HR	0	77	151,7018	19,13928	2,18112
	1	77	159,7746	23,03030	2,62455

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
Normal_HR	Equal variances assumed	5,428	,021	-2,366	152	,010	,019	-8,07283	3,41256	-14,81500	-1,33066
	Equal variances not assumed			-2,366	147,075	,010	,019	-8,07283	3,41256	-14,81681	-1,32885

We reject H0, there is significant different between the mean of max HR of the two sexes.

Independent t-test for cholesterol

Group Statistics

	Sex	N	Mean	Std. Deviation	Std. Error Mean
SMEAN(Cholesterol)	0	77	254,395	47,9030	5,4591
	1	77	236,702	40,7690	4,6461

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
SMEAN(Cholesterol)	Equal variances assumed	2,033	,156	2,468	152	,007	,015	17,6922	7,1685	3,5295	31,8550
	Equal variances not assumed			2,468	148,212	,007	,015	17,6922	7,1685	3,5266	31,8579

We reject H0, there is significant different between the mean of cholesterol of both sexes.

6 One Factor ANOVA

One Factor ANOVA

- The one-way analysis of variance (ANOVA) is used to determine whether there are any statistically significant differences between the means of two or more independent (unrelated) groups.
- Only **one independent variable** is checked for its impact on a **metric-dependent variable**

One Factor ANOVA

Example

- Does the type of chest pain experienced by people indicate anything about their Max HR?

One Factor ANOVA

Hypotheses:

- H0: There is no significant difference between the means of Max HR of the compared chest pain type groups.
- H1: **At least two** of the compared groups differ in mean of Max HR.

One Factor ANOVA

Assumptions

- From a random sample
- The dependent variable is continuous
- The dependent variable is normally distributed for each category
- There should be no significant outliers.
- There needs to be homogeneity of variances. This can be tested in SPSS using Levene's test for homogeneity of variances.

- Max HR is normally distributed for each category of chest pain type.

Tests of Normality

	Chest pain type	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
BP	1	.123	18	.200*	.943	18	.322
	2	.139	31	.132	.956	31	.227
	3	.121	71	.012	.979	71	.280
	4	.114	107	.002	.945	107	.000
Cholesterol	1	.143	18	.200*	.950	18	.420
	2	.135	31	.156	.938	31	.073
	3	.132	71	.004	.865	71	.000
	4	.040	107	.200*	.983	107	.173
Max HR	1	.128	18	.200*	.946	18	.368
	2	.127	31	.200*	.940	31	.083
	3	.095	71	.184	.926	71	.000
	4	.076	107	.160	.979	107	.085
ST depression	1	.129	18	.200*	.918	18	.121
	2	.316	31	.000	.688	31	.000
	3	.179	71	.000	.853	71	.000
	4	.158	107	.000	.868	107	.000

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

One Factor ANOVA

- The Levene test shows that the homogeneity of variance assumption might be violated.

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Max HR	Based on Mean	4.235	3	255	.006
	Based on Median	4.103	3	255	.007
	Based on Median and with adjusted df	4.103	3	252.313	.007
	Based on trimmed mean	4.297	3	255	.006

Results

- The ANOVA test tells us that at least two groups' means differ.
- The Brown-Forsythe test also shows a significance in the comparison of means.

ANOVA

Max HR

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17143.601	3	5714.534	12.217	.000
Within Groups	119279.156	255	467.761		
Total	136422.757	258			

Robust Tests of Equality of Means

Max HR

	Statistic[a]	df1	df2	Sig.
Brown-Forsythe	13.209	3	117.541	.000

a. Asymptotically F distributed.

- Tukey Post-hoc test indicates that there is a significant difference between the mean of type “4” and other types.

Multiple Comparisons

Dependent Variable: Max HR

Tukey HSD

(I) Chest pain type	(J) Chest pain type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	-3.337	5.975	.944	-18.79	12.11
	3	1.497	5.428	.993	-12.54	15.53
	4	15.916*	5.212	.013	2.44	29.39
2	1	3.337	5.975	.944	-12.11	18.79
	3	4.834	4.288	.673	-6.25	15.92
	4	19.253*	4.010	.000	8.88	29.62
3	1	-1.497	5.428	.993	-15.53	12.54
	2	-4.834	4.288	.673	-15.92	6.25
	4	14.419*	3.138	.000	6.30	22.53
4	1	-15.916*	5.212	.013	-29.39	-2.44
	2	-19.253*	4.010	.000	-29.62	-8.88
	3	-14.419*	3.138	.000	-22.53	-6.30

*. The mean difference is significant at the 0.05 level.

Results

- It is important to look at descriptives of the tested variable.

Descriptives

Max HR

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	20	156.90	21.740	4.861	146.73	167.07	114	190
2	38	160.24	19.500	3.163	153.83	166.65	103	202
3	77	155.40	18.446	2.102	151.22	159.59	96	187
4	124	140.98	23.919	2.148	136.73	145.24	71	186
Total	259	149.32	22.995	1.429	146.51	152.14	71	202

The results show that the average Max HR for people with chest pain type “4” is significantly lower than that of the remaining types.

Two Factors ANOVA

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Two Factors ANOVA

- **Two-Factor ANOVA** is a statistical method that analyzes the influence of two categorical independent variables on a single continuous dependent variable. Unlike One-Way ANOVA, which examines the impact of one factor,
- **Two-Factor ANOVA** enables us to unravel the individual and combined effects of two factors. By doing so, we can explore potential interactions between these factors and gain valuable insights from our data.

Data transformation

- We transformed 'Age Groups' to create more evenly distributed categories: (Group 1) 29 - 50, (group 2) 51 - 59, and (group 3) 60 - 79. This transformation was done to improve the validity of the test.

- Gender groups were transformed to a smaller sample size due to the large difference in participants between the two data samples.

- **'Sex' and 'Age Groups':**

  We have two categories for 'Sex': 0 and 1, representing different genders.

  The 'Age Groups' are labeled as 1, 2, and 3.

Descriptive Statistics - Understanding the Heart of the Matter

- Overall Mean 'Max HR'
- Variability in 'Max HR
- 'Sex' and 'Age Groups' Interaction
- 'Sex' and 'Max HR'
- 'Age Groups' and 'Max HR
- Sample Size

Descriptive Statistics

Dependent Variable: Max HR

Sex	Age_Groups	Mean	Std. Deviation	N
0	1	210.40	244.073	25
	2	152.48	14.603	23
	3	173.69	169.569	36
	Total	178.81	172.948	84
1	1	163.48	19.993	27
	2	151.77	23.683	39
	3	140.92	16.320	24
	Total	152.39	22.317	90
Total	1	186.04	169.699	52
	2	152.03	20.650	62
	3	160.58	131.997	60
	Total	165.14	121.581	174

Results

- Levene's Test of Equality of Error Variances
- Tests of Between-Subjects Effects
- Corrected Model and Effect Sizes
- Individual Factors
- Observed Power
- Eta-squared (η^2)

Levene's Test of Equality of Error Variances[a]

Dependent Variable: Max HR

F	df1	df2	Sig.
2.297	5	168	.047

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Sex + Age_Groups + Sex * Age_Groups

Tests of Between-Subjects Effects

Dependent Variable: Max HR

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	78662.533[a]	5	15732.507	1.066	.381	.031	5.332	.374
Intercept	4571100.947	1	4571100.947	309.828	.000	.648	309.828	1.000
Sex	29986.055	1	29986.055	2.032	.156	.012	2.032	.294
Age_Groups	37986.211	2	18993.105	1.287	.279	.015	2.575	.276
Sex * Age_Groups	15595.491	2	7797.745	.529	.590	.006	1.057	.136
Error	2478618.875	168	14753.684					
Total	7302685.000	174						
Corrected Total	2557281.408	173						

a. R Squared = .031 (Adjusted R Squared = .002)

b. Computed using alpha = .05

H0 and H1 Conclusion

H0 (Null Hypotheses):

There is no significant difference in the mean "Max HR" values between sexes (male and female).
There is no significant difference in the mean "Max HR" values among the three age groups (1, 2, and 3).
There is no significant interaction effect between "Sex" and "Age_Groups" on the mean "Max HR" values.

H1 (Alternative Hypotheses):

There is a significant difference in the mean "Max HR" values between sexes (male and female).
There is a significant difference in the mean "Max HR" values among the three age groups (1, 2, and 3).
There is a significant interaction effect between "Sex" and "Age_Groups" on the mean "Max HR" values.

Thank you