

Have we been exercising?



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STAT407 Group Project

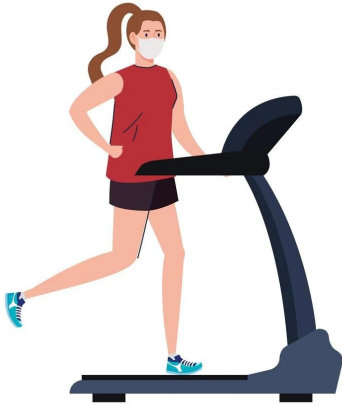
Outline

— — —

- Research Questions
- Data
- Methods
- Results
- Conclusions
- Additional Analysis

(1) Research Question

Research Question 1: Do the machine type, wearing a mask, and subjects affect the heart rate?



Data

- **Response:**

- heart rate(measure 3 times)

- **Factors:**

- machine (treadmill, elliptical)
- subject (Louis, Qing)
- mask (with or without)
- watch (Apple, Fitbit)

- **Procedure:**

1. Randomize the 3-factor combinations in R.
2. Measure subjects' heart rate using a phone app before the exercise.
3. Perform the exercise, meanwhile start a 10-minute workout on a smart watch, according to the randomized order.
4. Measure subjects' heart rate after the exercise using a phone app.
5. Cool down, record the average heart rate from the smart watch and wait until heart rate is back to resting heart rate.
6. Repeat Steps 2-5.

Method

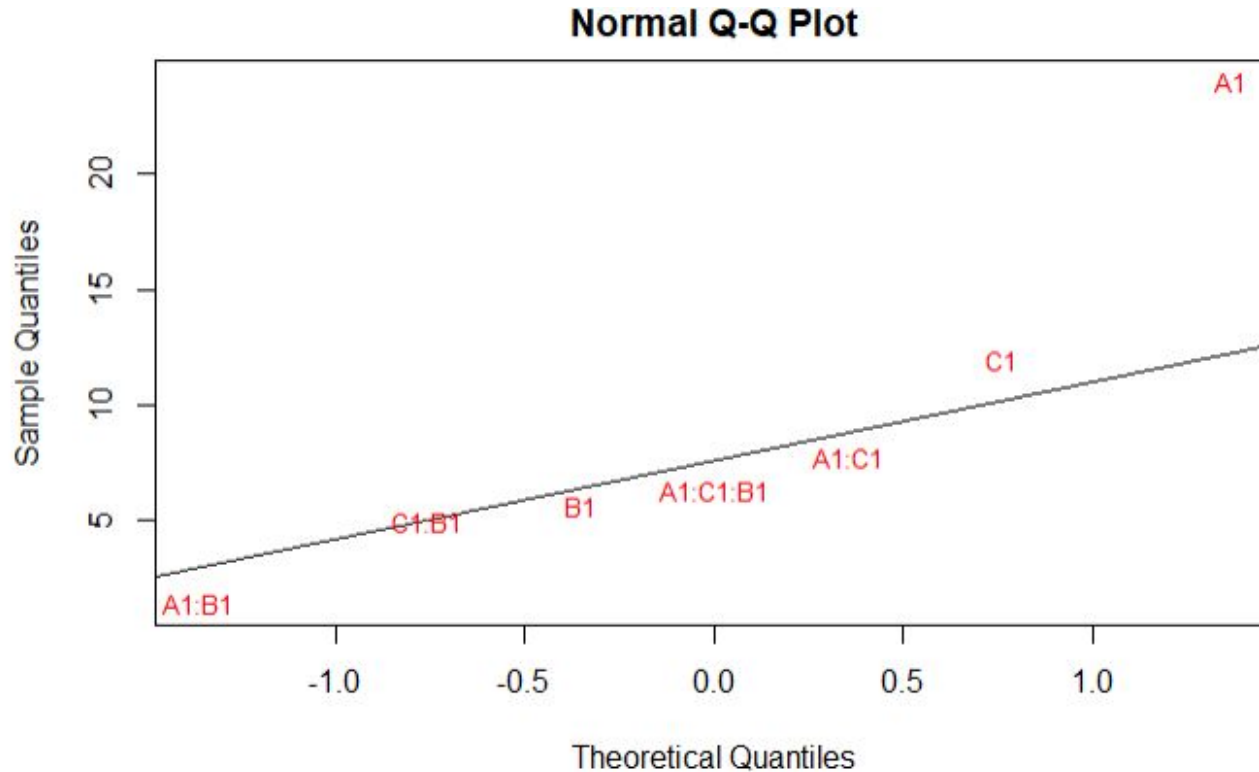
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(1) 2^3 Factorial Design without replicates

A	B	C	Difference
1	1	1	3
-1	-1	1	33
-1	1	1	29
1	-1	1	14
-1	1	-1	14
-1	-1	-1	20
1	1	-1	8
1	-1	-1	3

Factor	-1	+1
A: Machine	Elliptical	Treadmill
B: Mask	without	with
C: Subject	Louis	Qing

Half-Normal Plot of Effects



ANOVA

— — —

```
m2 <- lm(diff ~ A+C, data = data2)
anova(m2)
```

Analysis of Variance Table

Response: diff

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
A	1	578.0	578.0	18.1191	0.00804	**
C	1	144.5	144.5	4.5298	0.08659	.
Residuals	5	159.5	31.9			

Residual Assumptions

shapiro-wilk normality test

data: m2\$residuals
W = 0.89614, p-value = 0.2666

Bartlett test of homogeneity of variances

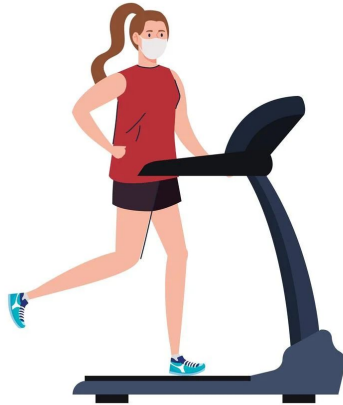
data: m2\$residuals and data2\$A
Bartlett's K-squared = 0.23357, df = 1, p-value = 0.6289

Bartlett test of homogeneity of variances

data: m2\$residuals and data2\$C
Bartlett's K-squared = 0.15026, df = 1, p-value = 0.6983

(2) Research Question

Research Question 2: Do watch brand, wearing a mask, and subject affect the reported heart rate while using the treadmill?



Method

— — —

(2) 2^3 Factorial Design with replicates

A	B	C	Difference
1	1	-1	53
1	-1	-1	36
-1	-1	-1	67
-1	1	-1	42
1	1	-1	35
1	-1	-1	64
-1	-1	-1	42
-1	1	-1	31
1	1	1	31
-1	-1	1	27
1	-1	1	22
-1	1	1	22
1	1	1	19
-1	1	1	24
1	-1	1	19
-1	-1	1	22

Factor	-1	+1
A: Watch	Apple	Fitbit
B: Mask	without	with
C: Subject	Louis	Qing

ANOVA Results (Full Model)

— — —

```
m2 <- lm(difference ~ (A+B+C)^3, data = proj.data)
anova(m2)
```

Analysis of Variance Table

Response: difference

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
A	1	0.25	0.25	0.0020	0.965732
B	1	110.25	110.25	0.8664	0.379185
C	1	2116.00	2116.00	16.6287	0.003545 **
A:B	1	81.00	81.00	0.6365	0.447998
A:C	1	6.25	6.25	0.0491	0.830161
B:C	1	182.25	182.25	1.4322	0.265661
A:B:C	1	9.00	9.00	0.0707	0.797007
Residuals	8	1018.00	127.25		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Results (Reduced Model)

— — —

```
##{r}
m4 <- lm(difference ~ B+C, data = proj.data)
anova(m4)
```

Analysis of Variance Table

Response: difference

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
B	1	110.25	110.25	1.1053	0.3122647
C	1	2116.00	2116.00	21.2130	0.0004925 ***
Residuals	13	1296.75	99.75		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

shapiro-wilk normality test

data: m4\$residuals
W = 0.94757, p-value = 0.4522

Bartlett test of homogeneity of variances

data: m4\$residuals and proj.data\$B
Bartlett's K-squared = 0.65668, df = 1, p-value = 0.4177

Bartlett test of homogeneity of variances

data: m4\$residuals and proj.data\$C
Bartlett's K-squared = 4.1936, df = 1, p-value = 0.04058

Results (Reduced Model)

```
##{r}
m4 <- lm(difference ~ B+C, data = proj.data)
anova(m4)
```

Analysis of Variance Table

Response: difference

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
B	1	110.25	110.25	1.1053	0.3122647
C	1	2116.00	2116.00	21.2130	0.0004925 ***
Residuals	13	1296.75	99.75		

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shapiro-wilk normality test

data: m4\$residuals
W = 0.94757, p-value = 0.4522

Bartlett test of homogeneity of variances

data: m4\$residuals and proj.data\$B
Bartlett's K-squared = 0.65668, df = 1, p-value = 0.4177

Bartlett test of homogeneity of variances

data: m4\$residuals and proj.data\$C
Bartlett's K-squared = 4.1936, df = 1, p-value = 0.04058

Results (Reduced Model)

```
```{r}
m5 <- lm(logdiff ~ B+C, data = proj.data)
anova(m5)
```
```

Analysis of Variance Table

Response: logdiff

| | Df | Sum Sq | Mean Sq | F value | Pr(>F) |
|-----------|----|---------|---------|---------|---------------|
| B | 1 | 0.03632 | 0.03632 | 0.6475 | 0.4355 |
| C | 1 | 1.76370 | 1.76370 | 31.4431 | 8.518e-05 *** |
| Residuals | 13 | 0.72919 | 0.05609 | | |

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

shapiro-wilk normality test

data: m5\$residuals
W = 0.93479, p-value = 0.29

Bartlett test of homogeneity of variances

data: m5\$residuals and proj.data\$B
Bartlett's K-squared = 0.040087, df = 1, p-value = 0.8413

Bartlett test of homogeneity of variances

data: m5\$residuals and proj.data\$C
Bartlett's K-squared = 0.8804, df = 1, p-value = 0.3481

Additional Analysis

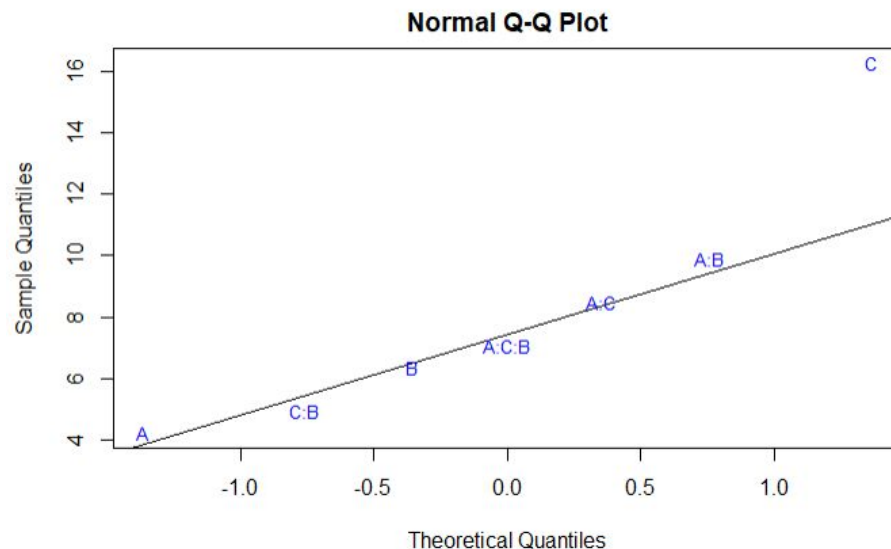
Confounding the 2^3 Factorial Design in Two Blocks

- ABC is confounded with two blocks.

■ TABLE 7.4

Table of Plus and Minus Signs for the 2^3 Design

| Treatment Combination | Factorial Effect | | | | | | | | Block |
|-----------------------|------------------|----------|----------|-----------|----------|-----------|-----------|------------|-------|
| | <i>I</i> | <i>A</i> | <i>B</i> | <i>AB</i> | <i>C</i> | <i>AC</i> | <i>BC</i> | <i>ABC</i> | |
| (1) | + | - | - | + | - | + | + | - | 1 |
| <i>a</i> | + | + | - | - | - | - | + | + | 2 |
| <i>b</i> | + | - | + | - | - | + | - | + | 2 |
| <i>ab</i> | + | + | + | + | - | - | - | - | 1 |
| <i>c</i> | + | - | - | + | + | - | - | + | 2 |
| <i>ac</i> | + | + | - | - | + | + | - | - | 1 |
| <i>bc</i> | + | - | + | - | + | - | + | - | 1 |
| <i>abc</i> | + | + | + | + | + | + | + | + | 2 |



Additional Analysis

```
m2 <- lm(avg-before ~ B+C + ABC, data =d2)
anova(m2)
```

Analysis of Variance Table

Response: avg - before

| | Df | Sum Sq | Mean Sq | F value | Pr(>F) |
|-----------|----|--------|---------|---------|-----------|
| B | 1 | 180.5 | 180.50 | 1.5851 | 0.27650 |
| C | 1 | 968.0 | 968.00 | 8.5005 | 0.04344 * |
| ABC | 1 | 32.0 | 32.00 | 0.2810 | 0.62410 |
| Residuals | 4 | 455.5 | 113.87 | | |

shapiro-wilk normality test

data: m2\$residuals
W = 0.89811, p-value = 0.2778

Bartlett test of homogeneity of variances

data: m2\$residuals and d1\$B
Bartlett's K-squared = 0.1024, df = 1, p-value = 0.749

Bartlett test of homogeneity of variances

data: m2\$residuals and d1\$C
Bartlett's K-squared = 0.30783, df = 1, p-value = 0.579

Bartlett test of homogeneity of variances

data: m2\$residuals and ABC
Bartlett's K-squared = 0.48585, df = 1, p-value = 0.4858

Conclusions

— — —

- RQ1 – Machine type has significant effect on the heart rate, subjects and wearing masks or not don't significantly affect the heart rate.
- RQ2 – Only subject significantly affects the reported heart rate, smartwatch brand and wearing masks or not have no effect.

Future Work

— — —

- Find elliptical machines with intensity level settings.
- Increase the level of intensity to medium or difficult.
- More subjects.
- Energy drinks as factor.

References

1. Epstein D., Korytny A., Isenberg Y., Marcusohn E., Zukermann R., Bishop B., Minha S., Raz A., Miller A. Return to Training in the COVID-19 Era: The Physiological Effects of Face Masks during Exercise. Scand. J. Med. Sci. Sports. 2021;31:70-75. doi: 10.1111/sms.13832. – DOI – PMC – PubMed
2. Myers J. Exercise and cardiovascular health. Circulation. 2003; 107:2e-5.
3. <https://www.fyzical.com/lakewoodranch/blog/What-Is-a-Cardiovascular-Exercise>