The Effects of Age, Gender, and Exercise Type on Physiological Stress Markers in Islander Populations

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Stats 101B Lecture 3 - Group L

Existing Literature

Cortisol and Adrenaline as Coordinated Stress Hormones: Cortisol plays a vital role in energy metabolism, immune function, and adaptation during exercise, while adrenaline supports immediate energy needs and cardiovascular output (Hackney & Walz, 2013)

Exercise Intensity Determines Cortisol Response: Moderate to high intensity exercise (≥60% VO_2 max) significantly increases cortisol levels, while low intensity exercise (40%) does not provoke a strong hormonal response (Hill et al., 2008)

Physical Activity Reduces Cortisol and Improves Sleep: Regular exercise is linked to lower cortisol levels and better sleep quality, but most studies focus on clinical populations (e.g., women with breast cancer) with little data on males or older adults (De Nys et al., 2022)

Age-Related Decline in Physical Activity: Physical activity declines by 40–80% with age due to biological and psychosocial factors, increasing vulnerability to chronic diseases and potentially altering hormonal stress responses (Suryadinata et al., 2020)

Gender Differences in Endurance Physiology: Men have higher VO_2max values due to anatomical advantages, but women show better pacing, fat utilization, and fatigue resistance in endurance exercise (Besson et al., 2022)

Research Question

How do biological stress responses vary by type of physical activity, and are these responses moderated by age and gender?

- Are there gender differences in physical endurance within the Islander population?
- Does age correlate with physical endurance in high-exertion tasks (e.g. swimming)?
- Are elevated blood hormone (adrenaline and cortisol) levels associated with increased physical activity?
- Is there a difference in blood hormone levels based on type of physical activity?

Methods

Participants: The study involved 90 healthy individuals from the Islander population, evenly split by gender and across three age groups (0–25, 26–50, 51+).

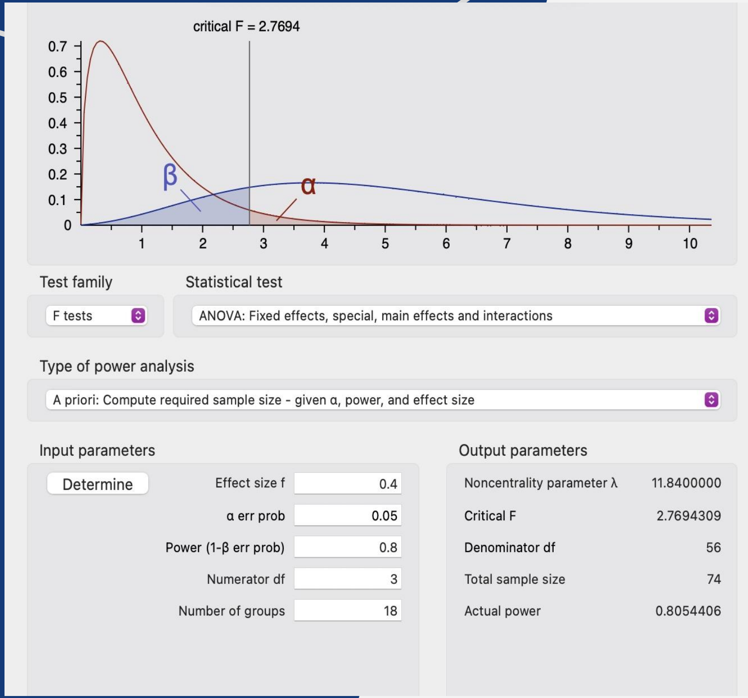
Experimental Design: A three-way factorial design examined the effects of exercise type, age group, and gender on changes in adrenaline, cortisol, and oxygen levels.

Instruments: Blood samples were analyzed for cortisol and adrenaline, and oxygen levels were measured via blood gas analyzers in mmHg.

Procedure: Participants completed one of three exercises (bungee jumping, jogging, or swimming), with blood drawn before and after to compute physiological changes.

Data Analysis: Data was analyzed using three-way ANOVA to assess main and interaction effects.

Sample Size Determination

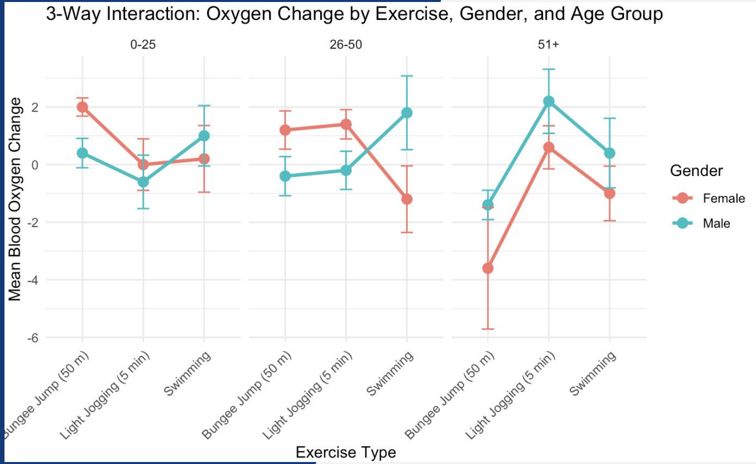


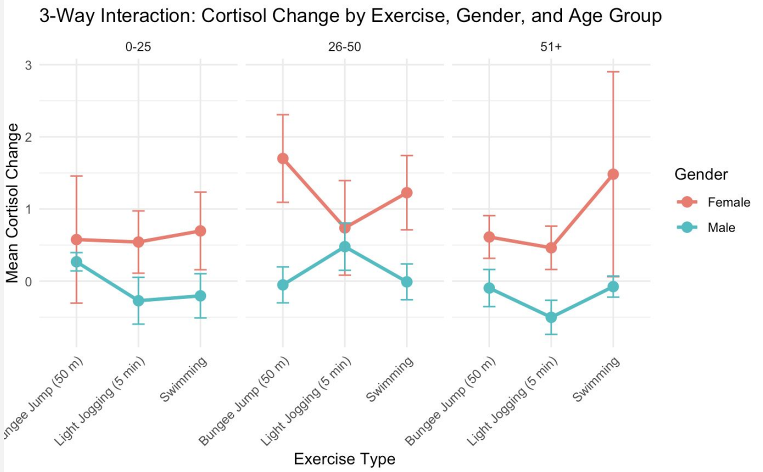
- Power level set to 0.80 and alpha = 0.05 (control for Type I and Type II errors)
- Effect size estimated at 0.40 (allowing for a more feasible sample size)
- Three-way factorial design with highest degrees of freedom = 3
- G*Power calculation estimated minimum N = 74
- To ensure a balanced design, we used 5 participants per group across 18 unique combinations (2 genders × 3 age groups × 3 activities)
- **Final sample size = 90 participants** (45 per gender and 15 per age bracket)
- Each participant completed only one activity to maintain independence in a between-subjects design.

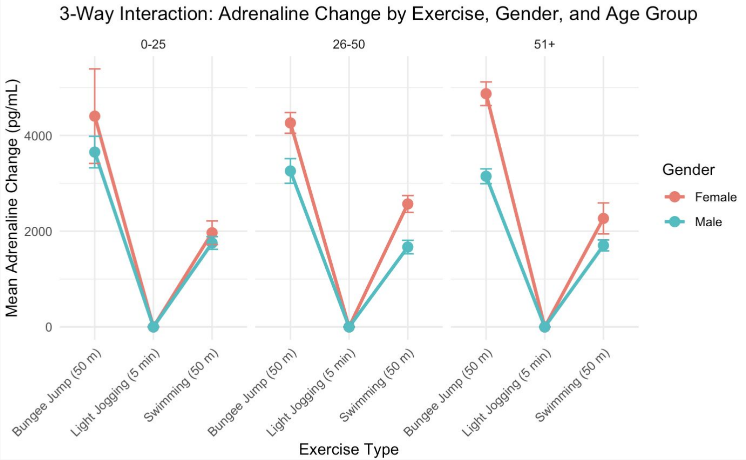
Experimental Design

- Open label study (participants and researchers both aware of treatment)
- Three-way between-subjects factorial design
- Independent variables:
    - Exercise Type: Bungee Jumping, Swimming, Light Jogging
    - Age Group: 0–25, 26–50, 51+
    - Gender: Male, Female
- Dependent variables:
    - Change in adrenaline, cortisol, and oxygen levels (post-exercise minus pre-exercise)
- 18 total groups (2 genders × 3 age groups × 3 activities), with 5 participants per group for a total of 90 participants
- Allows testing for main effects and interaction effects between all three factors using ANOVA

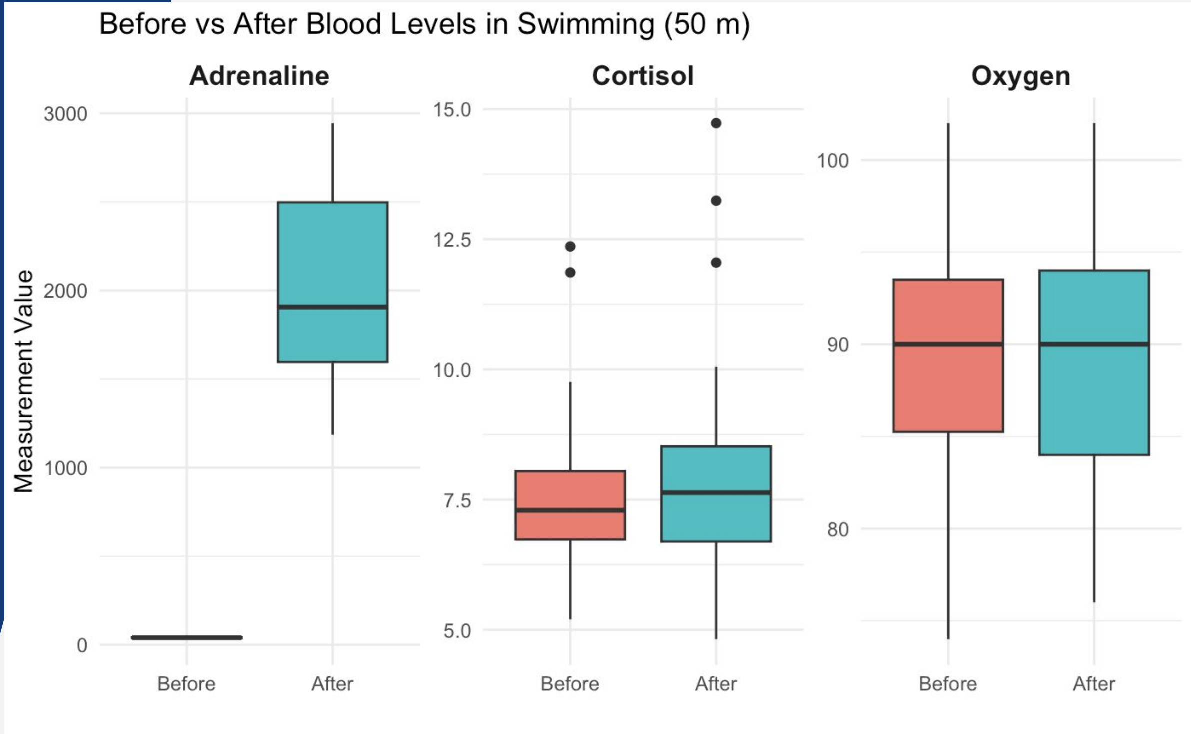
Results


3-Way Interaction: Oxygen Change by Exercise, Gender, and Age Group
0-25
26-50
51+
Mean Blood Oxygen Change
2
0
-2
-4
-6
Bungee Jump (50 m)
Light Jogging (5 min)
Swimming
Exercise Type
Gender
Female
Male


3-Way Interaction: Cortisol Change by Exercise, Gender, and Age Group
0-25
26-50
51+
Mean Cortisol Change
3
2
1
0
Bungee Jump (50 m)
Light Jogging (5 min)
Swimming
Exercise Type
Gender
Female
Male

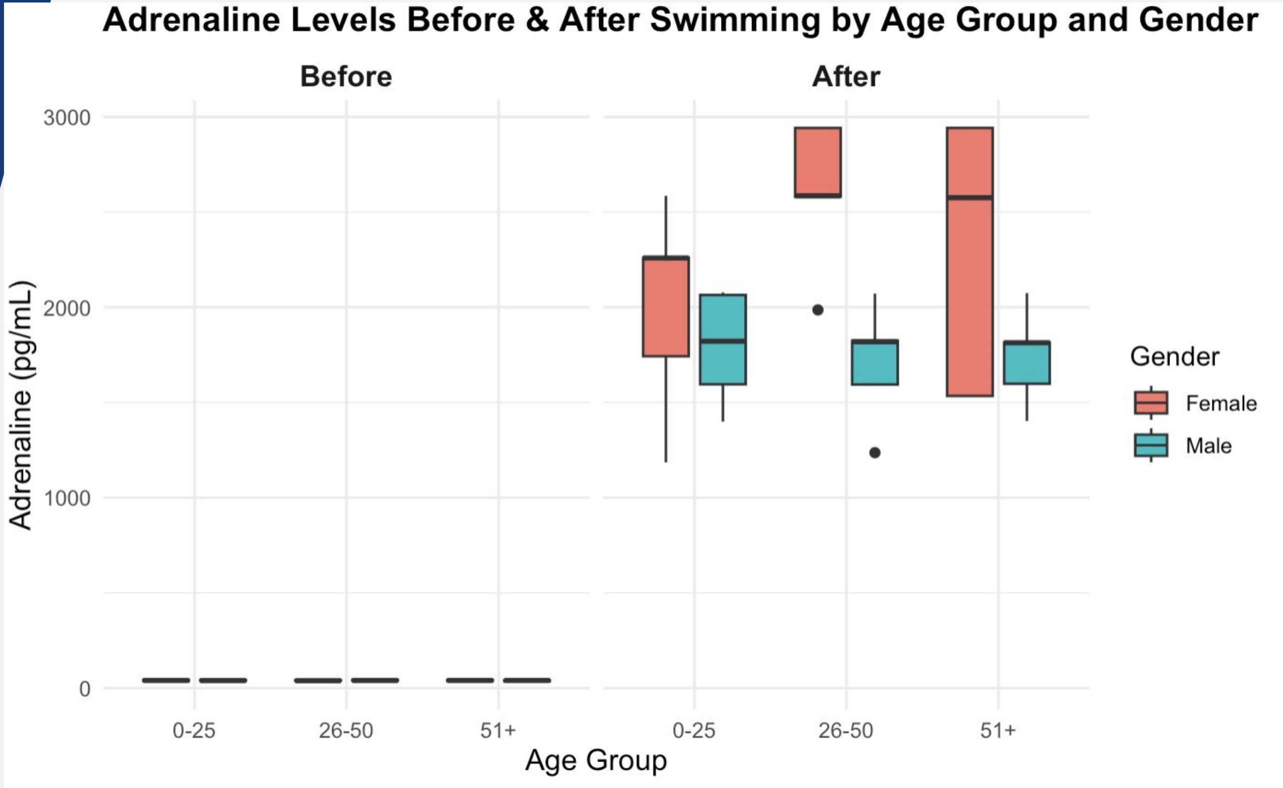

3-Way Interaction: Adrenaline Change by Exercise, Gender, and Age Group
0-25
26-50
51+
Mean Adrenaline Change (pg/mL)
4000
2000
0
Bungee Jump (50 m)
Light Jogging (5 min)
Swimming (50 m)
Exercise Type
Gender
Female
Male

Results



Before vs After Blood Levels in Swimming (50 m)
Adrenaline
Cortisol
Oxygen
Measurement Value
3000
2000
1000
0
15.0
12.5
10.0
7.5
5.0
100
90
80
Before
After
Before
After
Before
After

Results



Adrenaline Levels Before & After Swimming by Age Group and Gender
Before
After
3000
2000
1000
0
Adrenaline (pg/mL)
0-25
26-50
51+
0-25
26-50
51+
Age Group
Gender
Female
Male

Tukey HSD Test by Age

Tukey HSD Test: Cortisol Change by Age Group

	diff	lwr	upr	p adj
26-50-0-25	0.362	-1.329	2.053	0.855
51+-0-25	0.457	-1.234	2.148	0.780
51+-26-50	0.095	-1.596	1.786	0.989

Tukey HSD Test: Blood Oxygen Change by Age Group

	diff	lwr	upr	p adj
26-50-0-25	-0.3	-3.144	2.544	0.963
51+-0-25	-0.9	-3.744	1.944	0.712
51+-26-50	-0.6	-3.444	2.244	0.859

Tukey HSD Test: Adrenaline Change by Age Group

	diff	lwr	upr	p adj
26-50-0-25	258.47	-247.813	764.753	0.423
51+-0-25	124.60	-381.683	630.883	0.814
51+-26-50	-133.87	-640.153	372.413	0.788

Tukey HSD by Gender

Tukey HSD Test: Cortisol Change by Gender Group

	diff	lwr	upr	p adj
Male-Female	**-1.231**	**-2.372**	**-0.09**	**0.036**

Tukey HSD Test: Blood Oxygen Change by Gender Group

	diff	lwr	upr	p adj
Male-Female	1.733	-0.186	3.652	0.075

Tukey HSD Test: Adreneline Change by Gender Group

	diff	lwr	upr	p adj
Male-Female	**-559.18**	**-900.819**	**-217.541**	**0.002**

ANOVA Results

ANOVA Table: Cortisol Change by Age Group and Gender

term	df	sumsq	meansq	statistic	p.value
Age_Group	2	1.163	0.582	0.254	0.778
Gender	1	11.371	11.371	4.962	0.036
Age_Group:Gender	2	0.541	0.271	0.118	0.889
Residuals	24	55.001	2.292	NA	NA

ANOVA Table: Adreneline Change by Age Group and Gender

term	df	sumsq	meansq	statistic	p.value
Age_Group	2	334176.9	167088.5	0.813	0.455
Gender	1	2345117.0	2345117.0	11.412	0.002
Age_Group:Gender	2	587669.4	293834.7	1.430	0.259
Residuals	24	4932083.5	205503.5	NA	NA

ANOVA Table: Blood Oxygen Change by Age Group and Gender

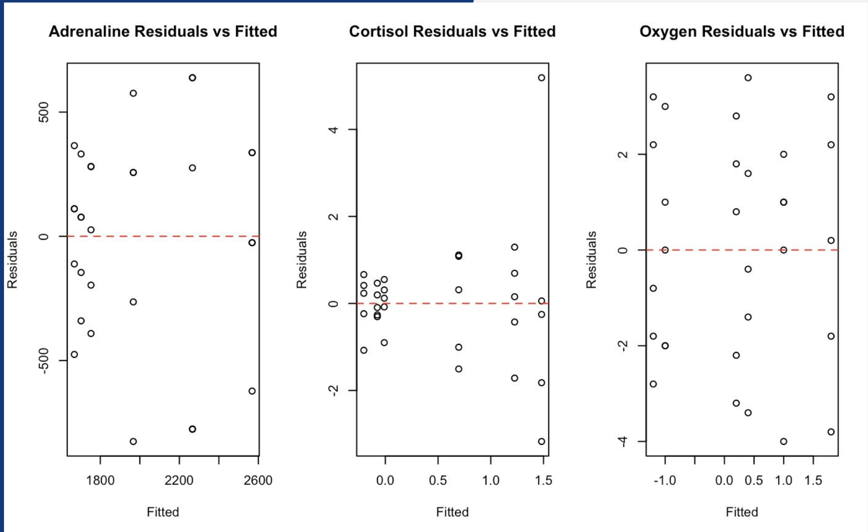
term	df	sumsq	meansq	statistic	p.value
Age_Group	2	4.200	2.100	0.324	0.726
Gender	1	22.533	22.533	3.476	0.075
Age_Group:Gender	2	6.467	3.233	0.499	0.613
Residuals	24	155.600	6.483	NA	NA

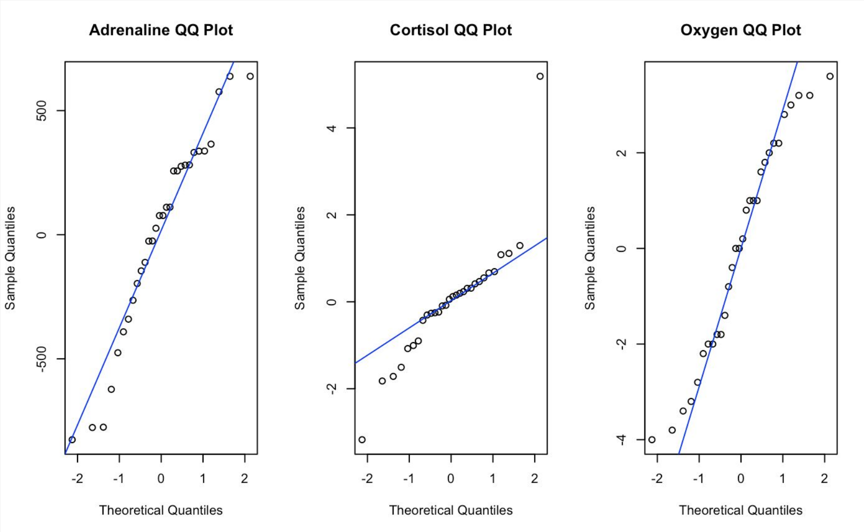
MANOVA Results

MANOVA Table: Blood Change Overall by Age Group and Gender

term	df	pillai	statistic	num.df	den.df	p.value
Age_Group	2	0.125	0.512	6	46	0.796
Gender	1	0.484	6.868	3	22	0.002
Age_Group:Gender	2	0.161	0.672	6	46	0.673
Residuals	24	NA	NA	NA	NA	NA

Residual and QQ Plot





Conclusions

Gender significantly influenced stress responses:

- Adrenaline change ($p = 0.002$)
- Cortisol change ($p = 0.036$)

Females had higher post-swimming adrenaline levels across age groups

- Especially in the 0–25 and 51+ groups (visualized in boxplots)

Tukey HSD confirmed significant gender difference in adrenaline ($p = 0.002$)

- No significant differences between age groups

Blood oxygen levels showed **no significant changes** by age or gender

Age × Gender interaction was **not significant** in any model

Key takeaway: Gender has a stronger effect than age on biological stress responses to high-exertion activity like swimming

Resources

De Nys, L., Anderson, K., Ofosu, E. F., Ryde, G. C., Connelly, J., & Whittaker, A. C. (2022). The effects of physical activity on cortisol and sleep: A systematic review and meta-analysis. Psychoneuroendocrinology, 143, 105843. https://doi.org/10.1016/j.psyneuen.2022.105843

Hackney, A. C., & Walz, E. A. (2013). Hormonal adaptation and the stress of exercise training: the role of glucocorticoids. Trends in sport sciences, 20(4), 165–171.

Hill, E. E., Zack, E., Battaglini, C., Viru, M., Viru, A., & Hackney, A. C. (2008). Exercise and circulating cortisol levels: the intensity threshold effect. Journal of endocrinological investigation, 31(7), 587–591. https://doi.org/10.1007/BF03345606

Suryadinata, R. V., Wirjatmadi, B., Adriani, M., & Lorensia, A. (2020). Effect of age and weight on physical activity. Journal of public health research, 9(2), 1840. https://doi.org/10.4081/jphr.2020.1840

Besson, T., Macchi, R., Rossi, J., Y. M. Morio, C,. Kunimasa, Y. et al. (2022) Sex Differences in Endurance Running. Sports Medicine, 52 (6), pp.1235-1257. ff10.1007/s40279- 022-01651-wff. ffhal-03991648