Effects of Exercise on Short-Term Cognition After Varying Recovery Intervals with a Focus on the Effects of Asthma

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Experimental Content, Design and Key Metrics

Key Response Variable of Interest: **Change in IQ** Before an Intense Multistage Fitness Test, and Afterwards

Experimental Design: **Basic Two-Way Factorial Design, with One Observational Factor and One Experimental Factor**

Observational Factor: **Asthma**

Treatment Factor: **Multistage Fitness Test** before a **rest period** of three levels – 5, 20, and 40 minutes

Factors of Interest: **Asthma** and **length of recovery interval**

Sample Size: **1902–half with asthma, and half without.**

Power: **Enough.**

- **Primary Questions:**
  - How does intense physical activity effect an individual's immediate ability to think critically in the short-term?
  - Do we see effects that indicate severe exhaustion? Do these effects give way to beneficial effects, such as high wakefulness or intensity? Do the reduction of stress, in the form of test anxiety, outweigh the costs of fatigue?
  - What role does asthma play? Is it so severe as to render many individuals so incapacitated that they cannot think clearly at all?

- **Procedure:**

- Create a little Python bot to scrape up all the Islanders and their information, ask them for consent, dropped those that were not interested, those that were dead, and those 4 years or younger.
- Divide them into 2 groups: asthmatic and not asthmatic – roughly a 1:7 ratio. Randomly sample the non-asthmatics into the same size sample as the asthmatics.
- Further divide these 2 groups into 3 groups each (6 total groups)--this time randomly. All groups took an IQ test, as I found that the other tests had extremely inconsistent scores for many of the same individuals, holding all else constant; IQ seemed the most comprehensive, reliable, and consistent. The groups were applied the experimental treatments at different levels. Two groups -- one from each type of observational sample -- was given one of the levels of rest period before taking the IQ test a second time. That is, two groups per rest period – no subject was tested for multiple levels, and all levels were tested by an equal number of subjects from both observational groups.
- Also, the initial IQ test was given at around the same time of day as the second test, so as to reduce the potential effects of sleepiness, grogginess, afternoon-lulls, etc., but on a different day, so as to reduce the potential effects of test fatigue and many other confounding effects associated with before and after testing.
- Finally, I calculated the difference in pre-exercise IQ and post-exercise + rest IQ, in order to account for individual intelligence levels and reduce the noise, which should in large part be cancelled out already given my large sample sizes, even further.

Findings

Anova with rest length as a factor and as numeric:
Table 1 -> aov(IQChange ~ Asthma*RestInterval)
Table 2 -> aov(IQChange ~ Asthma*MinutesRested)

	Deg. Freedom	Sum Squares	Mean Sum Sq.	F value	Pr(>F)
Asthma	1	273	272.6	3.537	0.0602 .
RestInterval	2	3136	1568.1	20.348	1.8e-09 ***
Asthma* RestInterval	2	148	74.2	0.963	0.3820
	1896	146115	77.1		

	Deg. Freedom	Sum Squares	Mean Sum Sq.	F value	Pr(>F)
Asthma	1	273	272.6	3.507	0.0613 .
MinutesRested	1	1890	1889.6	24.313	8.9e-07 ***
Asthma* MinutesRested	1	3	3.0	0.038	0.8447
	1898	147508	77.7		

Findings

I tried with IQ change as a percentage as well:
Table -> aov(Percentage_IQChange ~ Asthma* RestInterval)

	Deg. Freedom	Sum Squares	Mean Sum Sq.	F value	Pr(>F)
Asthma	1	861	861	4.394	0.0362 *
RestInterval	2	7760	3880	19.804	3.07e-09 ***
Asthma*Rest Interval	2	441	220	1.124	0.3251
	1896	371452	196		

When we calculate for percentage change in IQ:

- We **fail to reje**ct the null that there is no significant interaction effect between having asthma and how long you are given to recover, in terms of mental cognition/critical thinking, in addition to the main effects.

- We can **reject** the null that there is no significant effect of the observational factor - asthma.

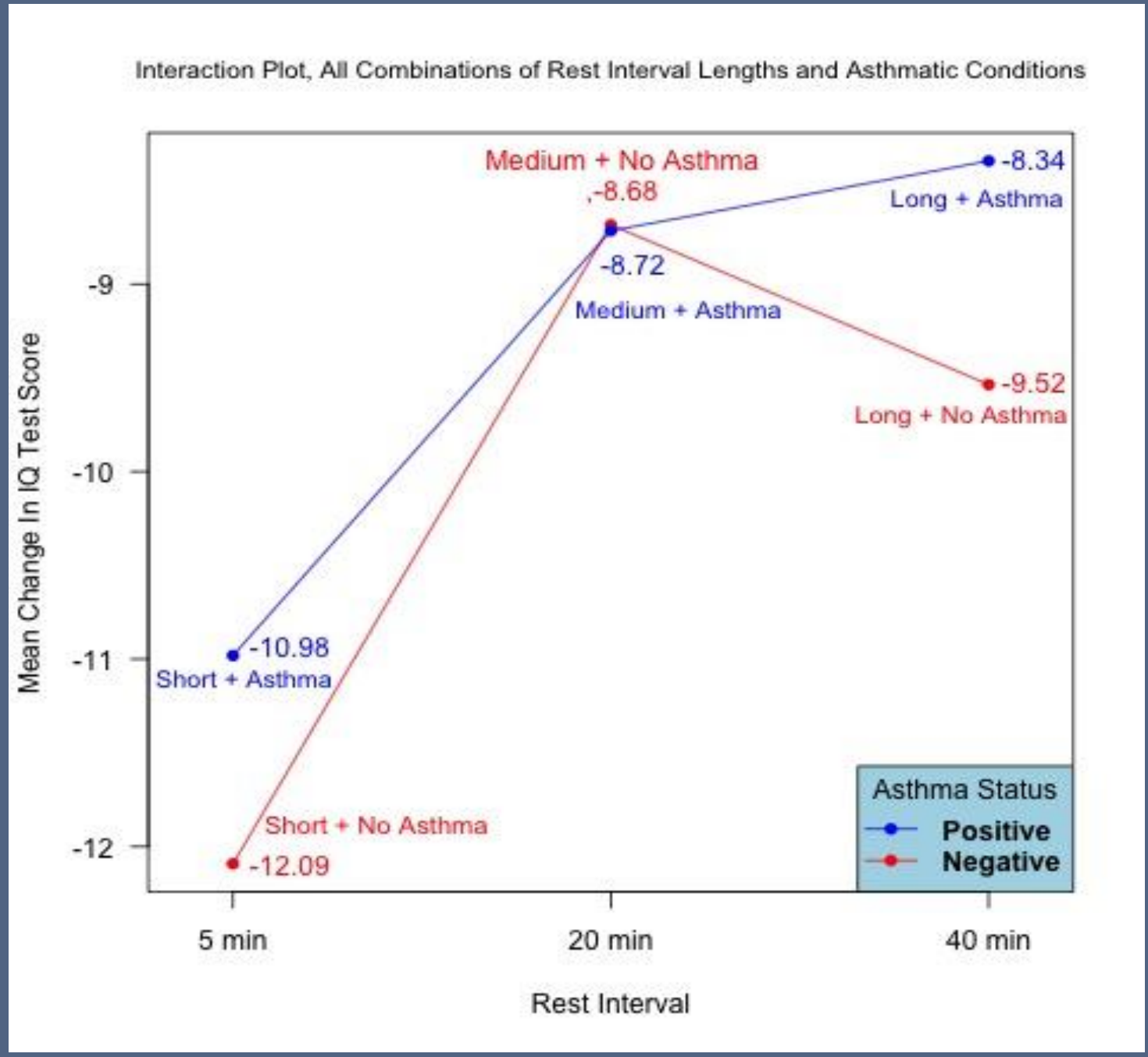
- We ***can*** also, by a wide margin in any anova analysis, **reject** the null that time intervals have no significant effect on the outcome variable or that there is no significant effect of the experimental factor – rest interval.

There is only a difference in hypothesis conclusions between anova on percentage change and anova on pure change for the observational factor's effect.

- Because it is so close to the .05 level of the absolute change anova model and it is below it for the percentage change model, I would, if I had to put my conclusion into a single statement, reject the null the the asthma factor has no effect on cognitive ability after exercise.

Interaction Plot

- An **marked interaction effect** occurs when the rest interval increases from **20 to 40 minutes**:
  - **The mean drop in IQ goes backward and increases further for the non-asthmatic group, despite the subjects getting even more rest, while decreasing slightly for the the asthmatic group.**
  - A possible explanation could be that at somewhere between 20 and 40 minutes the gradual reduction in potential dopamine , adrenaline or any corresponding short-term cognitive boosts from exercise begin to outweigh the cognitive benefits of short-term rest (for the average person with healthy lungs).
  - On the other hand, asthmatics may reap more benefits from the increased rest as they might still be catching their breath, so for them the net cognitive benefits remain positive.
  - Perhaps it is true that on the Island, there exists some threshold between 20 and 40 minutes where the decreased chemical boosts begin to slightly outweigh the increased rest.
  - Or perhaps there exists an unidentified factor which we failed to block for that has a very strong confounding effect that was not eliminated by a large randomly selected sample size and random assignments.
  - If we just consider the non-asthmatic, medium and long wait test groups and do a one-way anova looking at change in rest interval, it *barely* ails to be statistically significant – the p-value is 0.0552. If we add the asthmatics then it becomes far from significant, as suggested by the plot – the effects on each group are in opposite directions and thus balance out somewhat.
  - However, we can see that there is a significant interaction effection



Other Findings

- A basic two-sample t-test, comparing the mean IQ change for all asthmatics vs that on non-asthmatics, indicates some highly counterintuitive findings. Asthma does have a significant effect, but not in the downwards directions; asthmatics, on average, lose less points after exercise, for all rest interval lengths combined—though even if it is not by a lot and (barely*)* fails to be statistically significant.
- What's more, similar findings are apparent for Fitness Score. It appears that those with asthma are superior athletes on this Island. It's not by much, but the p-value is highly significant.
  - The latter finding more than likely indicates that variance between the two samples remains even though the sample sizes are very large.
  - On the other hand, the initial finding simply makes little to no sense. Even if variances exist, they would have to be pretty extraordinary to suggest that asthmatics have quicker recovery from intense exertion than do non-asthmatics, which across nearly 2,000 total samples, is extremely unlikely to be a chance occurrence.
  - Furthermore, by letting IQ Change be the response, I accounted for the differences in initial IQ between the the two samples so as to eliminate any potential confounding effect. This should almost entirely isolate our factor of interest – in the case asthma – from the innate differences in the sample populations. We've seen a couple counterintuitive findings, but this result is the least likely to be do to chance or confounding variance. It appears that the Island didn't put a great deal of effort into properly representing the symptoms of asthma, but this is merely a moot point as the Island is the reality in which we are experimenting in – not our own.

Mean Loss in IQ for Asthmatics	**Mean Loss in IQ for Non-Asthmatics**
-10.10	-9.35
Alt Hypothesis:	True difference in means is not equal 0
P-value:	0.0627
Mean Fitness Score for Asthmatics	**Mean Fitness Score for Non-Asthmatics**
8.25	7.95
Alt Hypothesis:	True difference in means is not equal 0
P-value:	1.065e-05

Future Testing and Limitations

- What's interesting is that **fitness score** and **age**, or **age groups** (5 - 17, 18 - 44, 45 – 64, 65- 84, 85+) especially, are the best predictors of IQ loss in MLR, and the two do go hand in hand a bit, while asthma doesn't really have much correlation with fitness score.
- Therefore, I think it would be instructive to block for age groups in the future, perhaps with blocks similar to the age groups outlined above. The average age is 32.17 for the asthmatic sample and 29.02 for the non-asthmatic sample, and a two-sample t.test indicates that there is a statistically significant difference depending on asthma status. Even though the sample sizes are extremely large and I accounted for variance in initial IQ between the two sample samples as well, I suppose there is perhaps enough variation in the ages of the individuals between the two samples to confound some of the findings to some degree. Again, it's impossible to know how the Island is programmed – an example of a scenario that could still lead to confounding despite all my efforts could be: perhaps exercise effects asthmatics in the adolescent age group far, far, far more than it does in the other age groups, the adolescent age group has a very sharp cutoff at age 13, and just by chance several dozen more adolescents are found in the non-asthmatic sample than in the asthmatic sample.
- I would also like to, in place of -- or in addition to -- the binary asthma column, add a binary column called **'AsthmaAttackInduced'**, which would indicate whether or not an individual is actually experiencing the symptoms. Though the Island says 'Dominic' *suffers* from asthma, it is -- both in reality and in this alternative reality as well -- very possible to be fit enough (or medicated enough) to avoid symptoms most of the time for many people.
- Finally, I was originally really interested in the interaction effect of exercise, cold weather and asthma all together. However not before long, I thought this would not be possible as the temperature is initially a '?' upon opening a village's URL, but I later found a pattern – the more southern a village is, the colder it is. This would allow for basic temperature grouping but recently I discovered how to identify the exact temperature for the villages in real-time – replace the relevant village's number for the '37' in the URL, 'http://island.maths.uq.edu.au/temperature.php?village=37&timezone=-7', and then this URL will lead to a page with where the only text is simply the village's temperature. Regardless, all was for naught, as this Island only accounts for the Australian climate and is always relatively quite warm in all villages.
    - Humidity and altitude would also be interesting to measure, for they often interact with asthma as well.
- Overall, further steps include:
    - **Induce asthma episodes as a treatment (assuming the Island doesn't care for ethics), or measure symptoms to store 1, for currently having an attack, and 0, for not, in a column**
    - **Block by age groups**
    - **Conquer Siberia and record the humidity and altitude for all of its villages as well**
    - **A partner or assistant would also be very helpful for the field work. Had I a second Island account, I could double the sample size. Also, it is quite demanding computationally to run all of these tests and create thousands of bots-- I usually had to set up kernels on my computer, on a desktop at the library, and on a library rental computer in order to run everything within a precise time intervals. So, with another person and another computer, even more tests could be conducted, without sacrificing sample size. A partner would most likely contribute some good ideas as well**