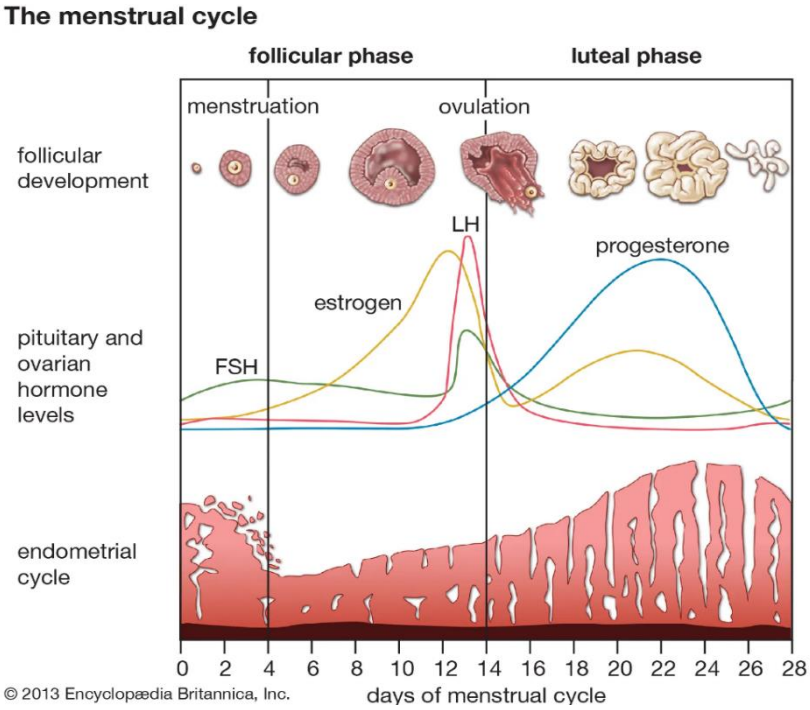
The Correlation Between the Phases of the Menstrual Cycle and Energy Levels

Menstruation is the process of the uterine lining shedding, which is a natural part of the female anatomy. Even though the menstrual cycle is something almost half of the population goes through, there are multiple misconceptions about it that people still hold onto to this day.

Despite the fact that the process of menstruation lasts only a couple of days, the menstrual cycle continues throughout the month and makes the body go through various significant hormonal and physiological changes, depending on the phase; making the cycle an important element in life, not just a nuisance that lasts up to a week. Inflicted changes can have substantial effects on the person's mental health, focus period, energy levels, mood etc. The hormonal changes are determined by the 4 phases of the menstrual cycle: menstruation, follicular, ovulation and luteal.



Menstruation lasts for approximately five days at the beginning of the cycle, after which there is a follicular phase that lasts until around day fourteen, and finally a luteal phase that lasts until the next menstruation.[1]

[1]Clayton, 2023

In the menstrual cycle, since estrogen and progesterone levels are at their lowest, it is expected for energy levels to lower. As the estrogen levels rise in the follicular phase, an improvement in energy levels is expected, with a peak at the start of ovulation. Right after an egg is released into and dissolved in the uterus, which is the actual ovulation phase, a dip in the estrogen, and therefore the energy levels are expected. After ovulation, with a significant increase in progesterone and a lesser increase in estrogen, luteal phase progresses. Progesterone may lead to low energy and a depressed mood, but the increase in estrogen may lead to different results depending on the person.[2]

The reason why I chose to proceed with this topic when it comes to my course project is that firstly, my menstrual data is the most important and steady data I have about myself. It is something I chart manually; therefore, it is very reliable and has been stored for a long period of time.

As someone who is passionate about bodybuilding, I noticed that my energy levels and strength fluctuate throughout the month. Therefore, while starting this project, I was hoping to find out if my menstrual cycle had a partial effect. I used the Flo app to download my menstrual cycle data.

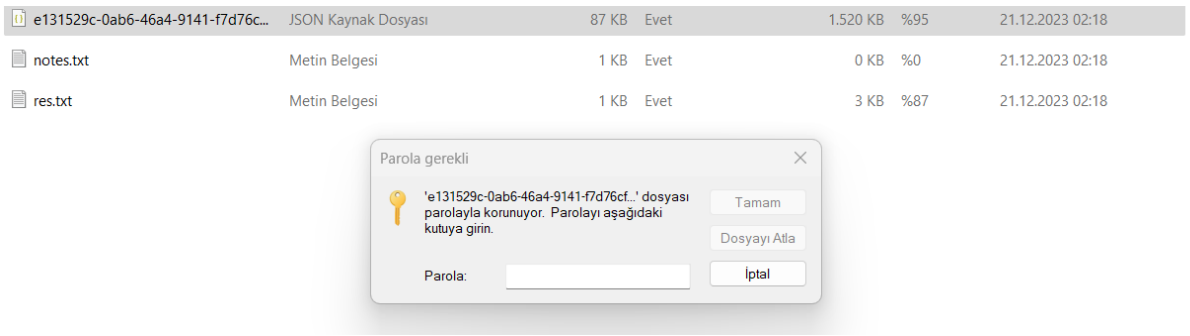
To test my energy and activity, I used my step counts taken from the Samsung Health App and my Netflix watch time as indicators. Since I practically take my phone everywhere with me, with minor exceptions, my step count is a good detector of my physical activity. My Netflix watch time is a good indication of inactivity, since I know for sure that I am stationary while my watch time increases (trust me on this one) and it is the only online streaming service that I use. Therefore, it makes up for most of my procrastination and relaxation time.

The step count and Netflix watch time data both came in the form of Excel sheets that were sent to me immediately, since they are not classified as particularly sensitive data. I just needed to go to the respective pages and create spreadsheets that had relevant information with dates, steps, watched shows etc. For Netflix watch time, I needed to manually update the durations of the shows, but as it turns out I am a very consistent watcher. I have found out that when I get loyal to a show, I stick with it until the end. Here is a very embarrassing snippet of my Netflix data where I watched nothing but Friends back to back for two weeks, which ended up with me binging 3 seasons all at once:

[2] (Street, 2022)

Friends: Season 6: The One with the Routine,"10/10/23"	22
Friends: Season 6: The One Where Ross Got High,"10/10/23"	22
Friends: Season 6: The One with Ross's Teeth,"10/9/23"	22
Friends: Season 6: The One Where Phoebe Runs,"10/9/23"	22
Friends: Season 6: The One on the Last Night,"10/8/23"	22
Friends: Season 6: The One with Joey's Porsche,"10/8/23"	22
Friends: Season 6: The One Where Joey Loses His Insurance,"10/8/23"	22
Friends: Season 6: The One with Ross's Denial,"10/8/23"	22
Friends: Season 6: The One Where Ross Hugs Rachel,"10/8/23"	22
Friends: Season 6: The One After Vegas,"10/8/23"	22
Friends: Season 5: The One in Vegas: Part 2,"10/8/23"	22
Friends: Season 5: The One in Vegas: Part 1,"10/7/23"	22
Friends: Season 5: The One with Joey's Big Break,"10/7/23"	22
Friends: Season 5: The One with the Ball,"10/7/23"	22
Friends: Season 5: The One with the Ride-Along,"10/7/23"	22
Friends: Season 5: The One Where Ross Can't Flirt,"10/7/23"	22
Friends: Season 5: The One Where Rachel Smokes,"10/6/23"	22
Friends: Season 5: The One with Rachel's Inadvertent Kiss,"10/6/23"	22
Friends: Season 5: The One with the Cop,"10/5/23"	22
Friends: Season 5: The One with the Girl Who Hits Joey,"10/5/23"	22
Friends: Season 5: The One Where Everybody Finds Out,"10/5/23"	22
Friends: Season 5: The One with Joey's Bag,"10/5/23"	22
Friends: Season 5: The One with Chandler's Work Laugh,"10/5/23"	22
Friends: Season 5: The One with All the Resolutions,"10/5/23"	22
Friends: Season 5: The One with the Inappropriate Sister,"10/4/23"	22
Friends: Season 5: The One with Ross's Sandwich,"10/4/23"	22
Friends: Season 5: The One with All the Thanksgivings,"10/4/23"	22
Friends: Season 5: The One Where Ross Moves In,"10/4/23"	22
Friends: Season 5: The One with the Yeti,"10/4/23"	22
Friends: Season 5: The One with the Kips,"10/3/23"	22
Friends: Season 5: The One Where Phoebe Hates PBS,"10/3/23"	22
Friends: Season 5: The One Hundredth,"10/3/23"	22
Friends: Season 5: The One with All the Kissing,"10/3/23"	22
Friends: Season 5: The One After Ross Says Rachel,"10/2/23"	22
Friends: Season 4: The One with Ross's Wedding: Part 2,"10/2/23"	22
Friends: Season 4: The One with Ross's Wedding: Part 1,"10/2/23"	22
Friends: Season 4: The One with the Worst Best Man Ever,"10/2/23"	22
Friends: Season 4: The One with the Invitation,"10/2/23"	22
Friends: Season 4: The One with the Wedding Dresses,"10/1/23"	22
Friends: Season 4: The One with All the Haste,"10/1/23"	22
Friends: Season 4: The One with Rachel's New Dress,"10/1/23"	22
Friends: Season 4: The One with the Free Porn,"10/1/23"	22
Friends: Season 4: The One with the Fake Party,"10/1/23"	22
Friends: Season 4: The One with All the Rugby,"9/30/23"	22
Friends: Season 4: The One with Joey's Dirty Day,"9/30/23"	22
Friends: Season 4: The One with Rachel's Crush,"9/30/23"	22
Friends: Season 4: The One with the Embryos,"9/30/23"	22
Friends: Season 4: The One with Phoebe's Uterus,"9/30/23"	22
Friends: Season 4: The One with the Girl from Poughkeepsie,"9/30/23"	22
Friends: Season 4: The One Where They're Going to Party,"9/30/23"	22
Friends: Season 4: The One with Chandler in a Box,"9/30/23"	22
Friends: Season 4: The One Where Chandler Crosses the Line,"9/30/23"	22
Friends: Season 4: The One with the Dirty Girl,"9/30/23"	22

The problematic part was my menstrual data, where I had my doubts about security and protection. Since the menstrual cycle is a data type most people would consider sensitive, the handling of it had more to anticipate. After a couple weeks of me asking the Flo app for my data, I received an e-mail that was protected by a passcode that was later provided to me. It is safe to say that the extra protective measure was appreciated.



The first method I used to clean up my data was to scrape the excel sheets and turn them into tables I could use to compare my cycles. Since dates are the most important and binding elements, I turned my Netflix watch time data and step count into two tables, starting from 22/07/2022 and ending at 30/11/2023.

Date	Total Duration (minutes)
2022-07-02 00:00:00	0.0
2022-07-03 00:00:00	0.0
2022-07-04 00:00:00	0.0
2022-07-05 00:00:00	50.0
2022-07-06 00:00:00	0.0
2022-07-07 00:00:00	0.0
2022-07-08 00:00:00	0.0
2022-07-09 00:00:00	120.0
2022-07-10 00:00:00	0.0
2022-07-11 00:00:00	0.0
2022-07-12 00:00:00	0.0
2022-07-13 00:00:00	0.0
2022-07-14 00:00:00	50.0
2022-07-15 00:00:00	0.0
2022-07-16 00:00:00	0.0
2022-07-17 00:00:00	125.0

	Date	Steps
0	2022-07-02	6754
1	2022-07-03	664
2	2022-07-04	8428
3	2022-07-05	1716
4	2022-07-06	7514
...	...	...
512	2023-11-26	13789
513	2023-11-27	2228
514	2023-11-28	9208
515	2023-11-29	9559
516	2023-11-30	9882

These were only for visualization purposes for the time being. When it comes to my menstrual data, I only needed to scrape the date part from the Flo app input. Therefore, the text file that provided me with all the start and end dates were enough. The Flo app provides many options to chart for women who are trying to conceive, and they were all available in the .json file that was included; such as certain symptoms, pain levels etc. But since all I needed was the dates for this particular project, the text file was sufficient for me to scrape.

The interesting part of the menstrual cycle scraping was that it was something I needed to do manually using mathematical calculations. Since human functionalities differ from month to month, I used calculations to create my menstrual phase database.

The 5-day menstrual phase is followed by a 10-day follicular phase. Then, a 5-day ovulation phase occurs. These time periods are mostly stable and are not affected by outside factors. However, the length of the cycle and therefore the duration of the luteal phase differs, with a couple day differences occurring from cycle to cycle. Therefore, some manual calculations were used to create my menstrual phase database.

The first thing I did was to assign each day to a menstrual cycle, step count and watch-time data. Some days there were no watch-times, which were assigned to 0. But other than those bits, I had no missing data.

Since the phase lengths differ, and it is not fair to compare total step counts and watch-times of different durations, I took the mean of every phase individually to find out if there was an actual difference, and if there could be a correlation between my energy levels and individual phases.

The overall average results came out as the following:

Average Step Counts:

Menstrual Cycle Phases

follicular phase 6419.737500

luteal phase 6711.583333

menstrual phase 6511.905882

ovulation phase 5729.662500

Average Watch Times:

Menstrual Cycle Phases

follicular phase 34.458613

luteal phase 33.719864

menstrual phase 36.202247

ovulation phase 39.664596

The overall averages showed that my step count data and watch-time data matched logically, and a correlation was possible. From these results it is safe to say that the luteal phase has the highest average step counts and smallest watch-time, indicating a rise in activity and energy levels. On the contrary, the ovulation phase has the least amount of average step count and the highest watch-time. The fact that on average I took 1000 less steps in the ovulation phase was the most significant finding for me.

Follicular and menstrual phases are normally back-to-back in the cycle as well, so it is not surprising to see that they have interchangeable result, with the menstrual phase having the slightly higher step count, and also the watch time.

From these tables only, we can assume that the sudden dip in the estrogen in the ovulation phase has a possible effect on my energy levels. As both progesterone and estrogen slowly rises in the luteal phase, it appears to be easier for me to get more activity.

Although the mean values help us look at the bigger picture, there can be outliers that mess with the mean calculation, such as a particularly active or inactive phases. Therefore, it is important to look more closely at each individual cycle and compare them within themselves, so as to learn more about phases specifically.

I had data corresponding to 16 cycles in total, making up almost a year and a half of data. Even though certain changes and irregularities are expected, the overall picture was pretty stable. Firstly, I created matrices with 16 cycles and their corresponding phases, then ranked the watch-times and steps within cycles. Here are the results for the step data:

	menstrual	follicular	ovulation	luteal
Cycle 1	5015.2	9031.8	5552.4	6661.8
Cycle 2	2470.4	4313.2	6636.8	6802.1
Cycle 3	6256.0	6204.9	4455.6	7193.1
Cycle 4	6013.8	5156.7	7656.4	7552.2
Cycle 5	6392.8	6542.0	6580.8	8455.5
Cycle 6	7566.8	6490.8	4986.0	5277.5
Cycle 7	6287.0	8366.6	5696.4	6390.2
Cycle 8	9624.0	10029.9	5987.4	10628.9
Cycle 9	8172.6	5701.6	2852.6	3154.9
Cycle 10	3119.6	2817.0	4658.0	5880.3
Cycle 11	5797.0	3400.9	3726.8	6301.8
Cycle 12	6376.8	7442.4	5574.2	7159.4
Cycle 13	5973.4	4146.8	8535.4	5360.4
Cycle 14	6867.4	5742.1	5128.8	5673.4
Cycle 15	9195.2	8020.1	6965.8	7634.3
Cycle 16	6641.2	9309.0	6681.2	7969.2

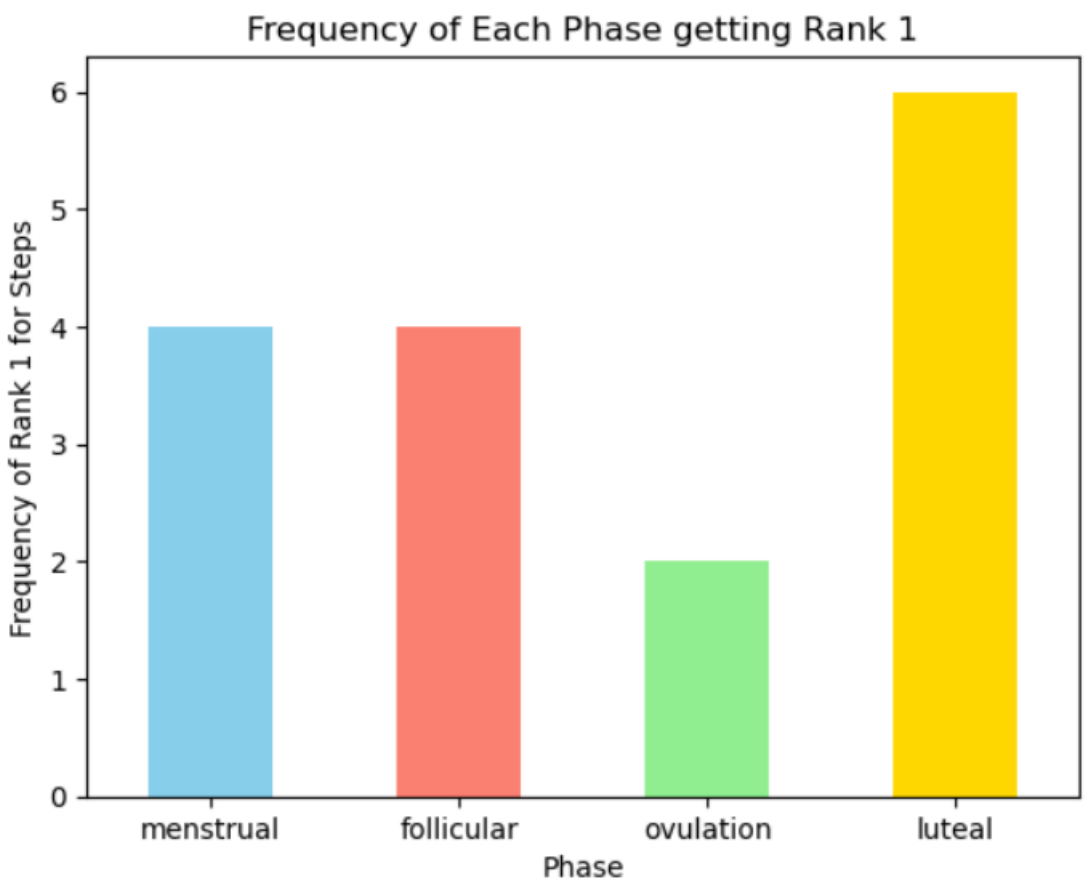
	menstrual	follicular	ovulation	luteal
Cycle 1	4.0	1.0	3.0	2.0
Cycle 2	4.0	3.0	2.0	1.0
Cycle 3	2.0	3.0	4.0	1.0
Cycle 4	3.0	4.0	1.0	2.0
Cycle 5	4.0	3.0	2.0	1.0
Cycle 6	1.0	2.0	4.0	3.0
Cycle 7	3.0	1.0	4.0	2.0
Cycle 8	3.0	2.0	4.0	1.0
Cycle 9	1.0	2.0	4.0	3.0
Cycle 10	3.0	4.0	2.0	1.0
Cycle 11	2.0	4.0	3.0	1.0
Cycle 12	3.0	1.0	4.0	2.0
Cycle 13	2.0	4.0	1.0	3.0
Cycle 14	1.0	2.0	4.0	3.0
Cycle 15	1.0	2.0	4.0	3.0
Cycle 16	4.0	1.0	3.0	2.0

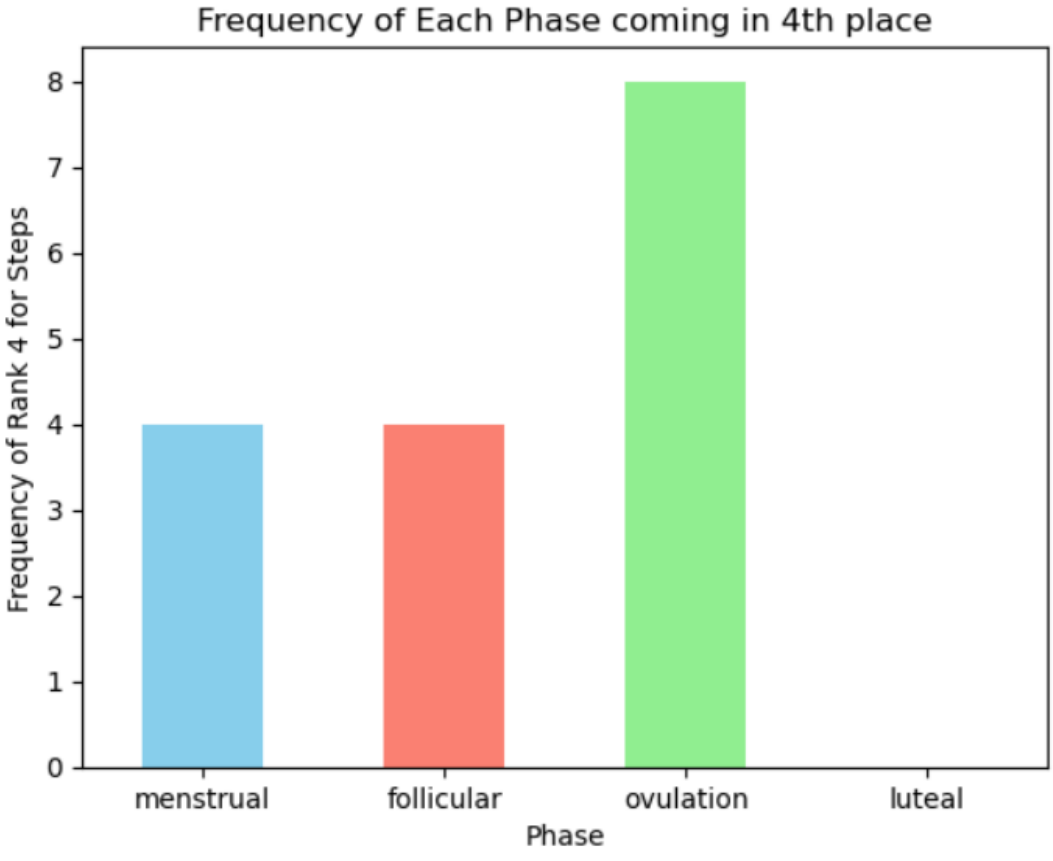
The same process was repeated for the watch time data as well:

	menstrual	follicular	ovulation	luteal
Cycle 1	50.0	85.0	91.2	45.0
Cycle 2	82.5	66.2	40.0	30.3
Cycle 3	0.0	38.2	50.0	30.8
Cycle 4	67.5	41.7	82.5	53.4
Cycle 5	15.0	52.5	50.8	48.0
Cycle 6	70.0	82.0	75.0	30.0
Cycle 7	30.4	23.0	45.2	61.9
Cycle 8	32.9	23.3	50.0	26.4
Cycle 9	50.0	61.7	27.5	32.4
Cycle 10	40.0	49.2	60.0	50.0
Cycle 11	48.5	20.9	22.5	24.3
Cycle 12	28.2	43.1	51.8	58.9
Cycle 13	58.2	52.5	47.0	33.6
Cycle 14	40.0	42.4	42.4	27.2
Cycle 15	30.9	22.1	22.0	28.2
Cycle 16	23.4	31.0	30.0	33.8

	menstrual	follicular	ovulation	luteal
Cycle 1	3	2	1	4
Cycle 2	1	2	3	4
Cycle 3	4	2	1	3
Cycle 4	2	4	1	3
Cycle 5	4	1	2	3
Cycle 6	3	1	2	4
Cycle 7	3	4	2	1
Cycle 8	2	4	1	3
Cycle 9	2	1	4	3
Cycle 10	4	3	1	2
Cycle 11	1	4	3	2
Cycle 12	4	3	2	1
Cycle 13	1	2	3	4
Cycle 14	3	1	1	4
Cycle 15	1	3	4	2
Cycle 16	4	2	3	1

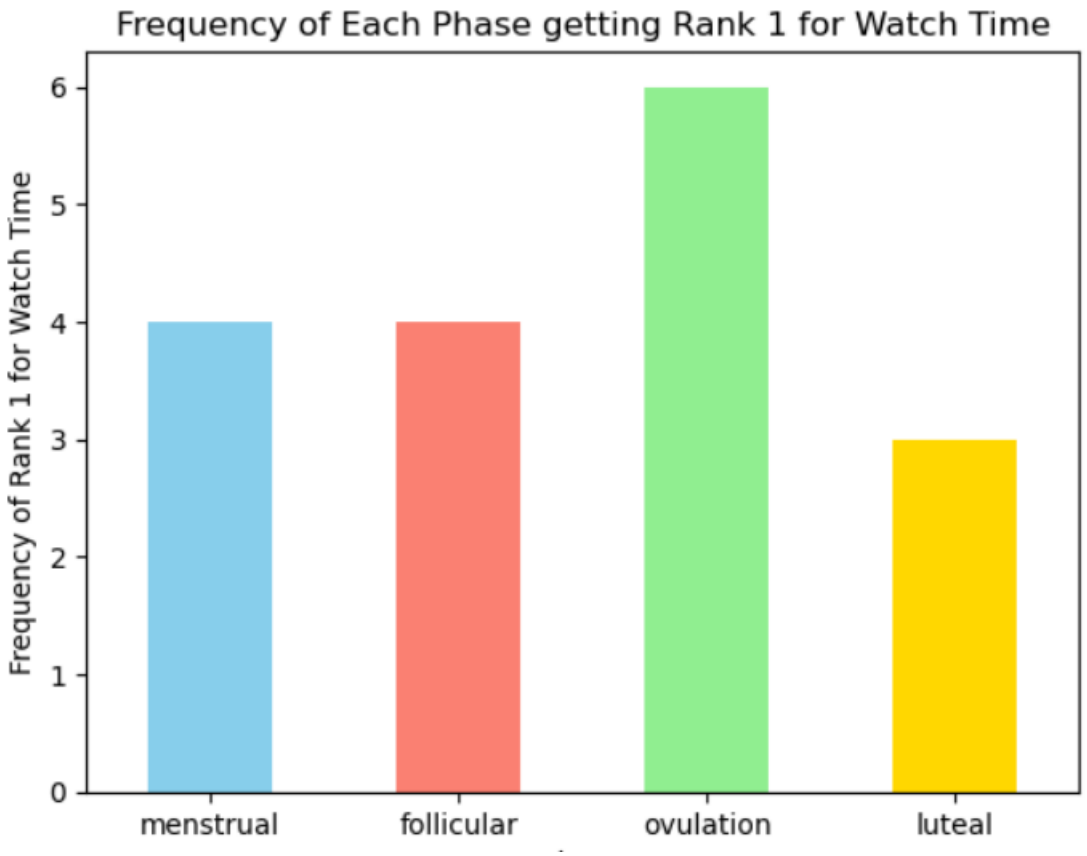
The next step was to compare how many times each phase got the most or least step count and watch time. This step was calculated to understand if there was an overall dominance like I expected. The output was as follows:

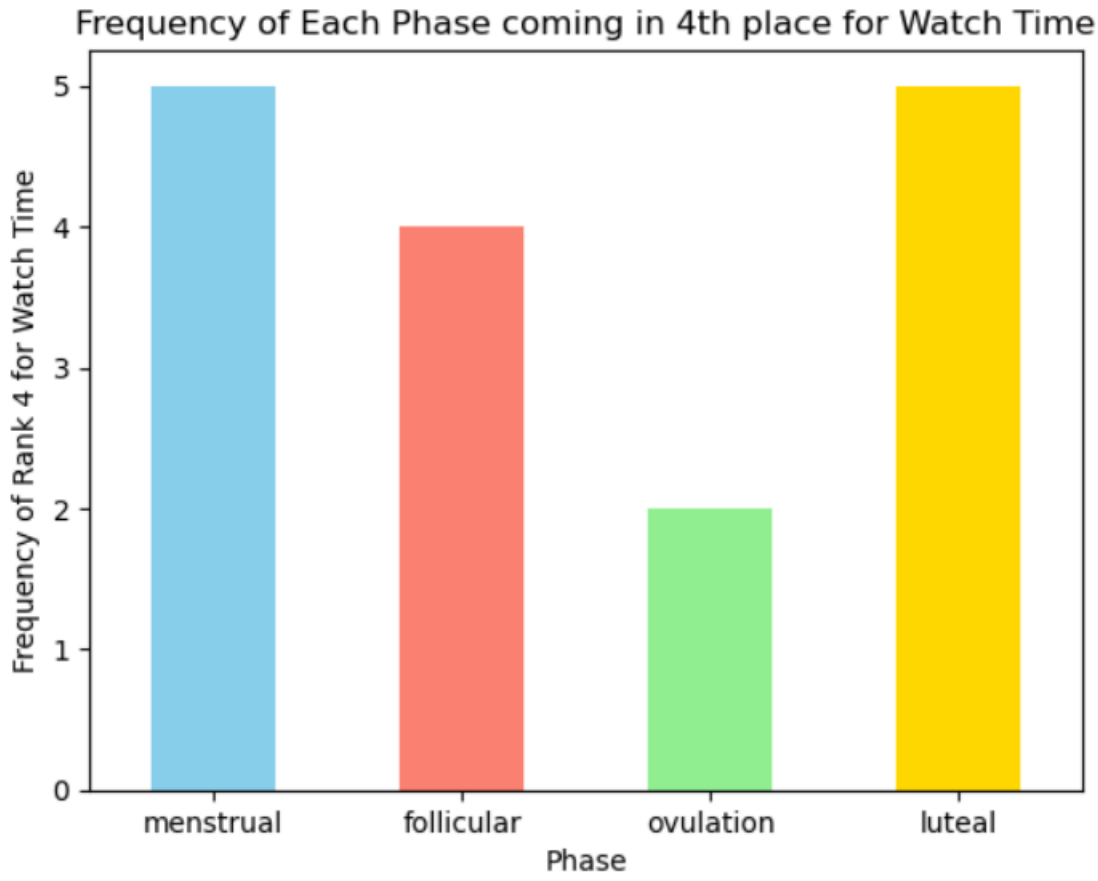

Frequency of Each Phase getting Rank 1
Frequency of Rank 1 for Steps
0
1
2
3
4
5
6
menstrual
follicular
ovulation
luteal
Phase


Frequency of Each Phase coming in 4th place
Frequency of Rank 4 for Steps
0
1
2
3
4
5
6
7
8
menstrual
follicular
ovulation
luteal
Phase

These charts indicate that it wasn't an outlier that caused the overall mean to be the way it is, but the fact that luteal phase consistently ranked higher when it comes to the step count, and the ovulation phase consistently ranked lower. The menstrual and follicular phases were close in calculations, with negligible differences, which is expected given they are back-to-back and there are no drastic hormonal changes for the most part.

The same calculations were applied to the watch time data as well, and the resulting bar charts are as follows:





Although the difference isn't as drastic as it was in the steps data, we can still see the correlation between higher watch time and being first to last ratio.

Later on, I decided to do use Correlation Matrix method to see if there was an actual correlation between the phases within themselves, according to their ranking. The results were as follows:

```
Correlation Matrix for Steps:
            menstrual  follicular  ovulation    luteal
menstrual    1.000000    0.578882  -0.051479  0.217399
follicular   0.578882    1.000000   0.147799  0.531144
ovulation   -0.051479    0.147799   1.000000  0.438733
luteal       0.217399    0.531144   0.438733  1.000000

Rank Correlation Matrix for Steps:
            menstrual  follicular  ovulation    luteal
menstrual    1.000000   -0.097179  -0.440660 -0.639091
follicular  -0.097179    1.000000  -0.691547 -0.308964
ovulation   -0.440660   -0.691547   1.000000  0.212792
luteal      -0.639091   -0.308964   0.212792  1.000000
```

The correlation matrix for steps data reveals moderate positive correlations between certain menstrual cycle phases, such as "menstrual" and "follicular," while negative correlations exist between other phases like "ovulation" and "menstrual." The rank correlation matrix, considering the ordinal nature of the data, shows similar patterns with stronger negative correlations, particularly pronounced between "menstrual" and other phases like "follicular" and "ovulation." These results suggest potential associations between menstrual cycle phases

and step counts, with notable differences in the strength of correlations based on rank analysis.

The same analysis is done for the watch time as well:

```
Correlation Matrix for Watch Time:
            menstrual  follicular  ovulation    luteal
menstrual    1.000000    0.508688   0.266733 -0.133724
follicular   0.508688    1.000000   0.591257  0.037075
ovulation    0.266733    0.591257   1.000000  0.446231
luteal      -0.133724    0.037075   0.446231  1.000000

Rank Correlation Matrix for Watch Time:
            menstrual  follicular  ovulation    luteal
menstrual    1.000000   -0.258115  -0.521669 -0.319747
follicular  -0.258115    1.000000  -0.152828 -0.526637
ovulation   -0.521669   -0.152828   1.000000 -0.190586
luteal      -0.319747   -0.526637  -0.190586  1.000000
```

The correlation matrix for watch time data shows moderate positive correlations between "menstrual" and "follicular," and "follicular" and "ovulation," indicating potential associations between these phases and watch time. However, negative correlations are observed between "menstrual" and "luteal," and "ovulation" and "luteal." The rank correlation matrix, considering the ordinal nature of the data, reveals stronger negative correlations, particularly notable between "menstrual" and other phases like "ovulation" and "luteal." These results suggest potential links between menstrual cycle phases and watch time.

Later on, I used the ANOVA test to compare the step means of the "menstrual," "follicular," "ovulation," and "luteal" phases to determine if there are statistically significant differences among them. The test calculates an F-statistic and a p-value.

In the provided result:

The F-statistic is approximately 0.91.

The p-value is approximately 0.44.

The p-value is used to assess the statistical significance of the F-statistic. A small p-value (typically less than the chosen significance level, e.g., 0.05) indicates that there is enough evidence to reject the null hypothesis. In this case it appears too high to reject, which is expected since my data is limited to a year and a half of cycles only, and the numbers appear relatively close.

As for the watch time result:

The F-statistic is approximately 1.01.

The p-value is approximately 0.39.

It is observed that the p-values are pretty close to one another. Even though these results are not significant enough to fully reject the null hypothesis, it is important for me to learn that there is actually a difference in my activity levels that are not ignorable, by my own standards.

Still, I believe this data shows potential and with further research and data collection, I might be able to have a stronger case against the importance of hormone levels when it comes to mood and energy.

To finalize everything I went through, it is important to keep in mind that my activity levels can be skewed thanks to school, exam periods, online education etc. Still, I believe when the bigger picture is kept in mind, there seems to be a pattern of inactivity and likelihood to procrastinate once the ovulation phase comes along.

This project made me learn more about my monthly activity habits, possible laziness and oddly terrifying Netflix binging habits. As I have mentioned before, as someone who is serious about weightlifting, this project was very helpful when it comes to organizing my workout schedule and being more mindful of my body.

There is a particular reason why I wanted use my menstrual data in this project. Firstly, I wanted to see how easy it was for an outsider to get a hold of my data. For example, Samsung Health application lets you track your period but doesn't let you share it with any other program, there is no way of scraping. Even though I was assigned a password for it and it took me a while to get a hold of it, I eventually found out that my menstrual data is passable and not particularly hard for people to steal. But why would that pose a problem in the first place? Even though it is still considered a taboo and people refrain from talking about it publicly, the menstrual cycle should not be worthy enough to steal in data form.

SPECIAL SERIES

Reproductive rights in America

How period tracking apps and data privacy fit into a post-Roe v. Wade climate

UPDATED JUNE 24, 2022 · 3:06 PM ET

By Rina Torchinsky

Following the ruling by the Supreme Court to overturn the Roe v. Wade decision in America, privacy experts are becoming more and more concerned about the possibility that information gathered from various applications, including period-tracking apps, might be utilized to

penalize anyone who is considering or has sought an abortion. The app I opted for to get my data, Flo, is used by 43 million people approximately.[3]

The start and end dates alone can be used to indicate irregularities or if there have been pregnancies; and when sold to a third party, a person's reproductive rights, therefore their life could be in danger. Even though the overturning of Roe v. Wade might seem like it is an issue only surrounding America, the unfortunate events concern everyone who has a right to choose what they want to do with their body (which is everybody!)

If further researched and collaborated with more data from various other people, this project can turn into something that can help others learn more about their bodies. Our bodies are vessels that help us get through life, therefore it is highly beneficial to further learn how it functions. My biggest short coming with this project was the fact that I only depended on my own, relatively short data, which diminished its higher purpose of being of help to multiple people. Therefore, given the opportunity this project can help people manage everyday life better.

Sources

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[3] (Torchinsky, 2022)