The Effects of COVID-19 on US Exercise Behavior

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# Abstract

The new coronavirus disease that emerged in 2019, COVID-19, modified many day-to-day behaviors in the United States (Tynan & Howard, 2020). Certain behaviors changed naturally, such as Netflix viewing habits, while others changed in accordance with government orders, such as restriction of indoor restaurant dining (Gostin & Wiley, 2020). One aspect of day-to-day behavior in the US that seemingly changed both naturally and as a result of government orders was exercise (Ramirez-Campillo & Souza, 2020). Exercise behaviors are a significant component of overall American health, and this project will analyze apparent changes in these behaviors since the onset of COVID-19. More specifically, this project will use public data to measure changes in seven different types of US exercise routine. The goal of this project is to increase knowledge pertaining to US behavioral changes since the pandemic began with a healthy focus on exercise.

# Problem Statement

COVID-19 was declared a global pandemic by the World Health Organization on March 11, 2020 (WHO, 2020). In response, the United States declared a national emergency on March 13, 2020 to slow the spread of the virus. Regarding guidelines for exercise, the national emergency declaration implemented commercial gym closures, discouraged the sharing of fitness equipment, and ordered the cessation of group exercise when ten or more people were in attendance (Ramirez-Campillo & Souza, 2020). Although these government orders did not halt exercise in the US, they altered it in numerous ways:

* People habitually exercising at commercial gyms had to exercise at home or elsewhere.
* People exercising with public equipment had to find their own equipment or change the equipment they exercised with (i.e., those using weights at a commercial gym).
* People exercising in groups had to exercise in smaller groups or alone (i.e., those attending exercise classes).

For commercial gyms, fitness equipment manufacturers, fitness apparel brands, nutritional supplement brands, fitness instructors/coaches, and many more participants in the fitness industry, the three exercise alterations listed above are critical. The resulting alterations to US exercise behavior have significantly altered the fitness industry as a whole. To gain insight into these changes, this project focuses on the following question:

* Which types of exercise are more popular in the US post-COVID-19?

# Literature Review

## COVID-19 Timeline and Government-Imposed Business Closures

The new coronavirus disease that emerged in 2019, COVID-19, was declared a global pandemic by the World Health Organization on March 11, 2020 (WHO, 2020). In response, the United States declared a national emergency on March 13, 2020 to slow the spread of the virus. The national emergency imposed school closures, nonessential businesses closures, cancellation of large public gatherings, cancellation of sporting and entertainment events (Chowell, 2020), travel restrictions, quarantines for travelers, and stay-at-home orders implemented by governors and mayors (Gostin & Wiley, 2020). In relation to exercise, these government orders closed commercial gyms, discouraged the sharing of fitness equipment, and demanded the cessation of group exercise when ten or more people were in attendance (Ramirez-Campillo & Souza, 2020).

## COVID-19 US Attitude Changes and the New Normal

As a result of the global pandemic and the US national emergency, the behaviors and attitudes of members of the US public changed. Surveys from May 5-12, 2020 revealed that US citizens began to avoid gathering in groups of ten or more persons and complied with rules that prohibited inside dining (Tynan & Howard, 2020). Another study by the CDC showed a drastic decrease in US population movement from state-to-state during the months of March, April, and May of 2020 (Herlihy & Tynan, 2020). These changes are continually shaping a “new normal” in the United States (Roberts & Tehrani, 2020).

Some early and obvious differences inherent to this “new normal” have already been well covered, such as the increased number of people working from home (Ahmad, 2020) and the rise in Netflix subscriptions (Dias, 2020). Thus far, however, there has not been extensive research examining the “new normal” regarding US exercise habits and behaviors. Therefore, this project will examine the changes that have taken place in this important aspect of American behavior relevant to health (Fletcher et al., 1992)

## Relationship between Podcast Data and US Exercise Behavior

As humans, our interests are complicated and varied, with differing degrees of magnitude and purpose. For this project, it is important to consider that we are interested in topics that are relevant to ourselves (Tobarra et al., 2014). This link between interest and relevancy is important, although not perfect, because it allows us to use data regarding interest as a proxy for relevance.

One source of data regarding interest that is prevalent and available to us is podcast data. Podcasts have dramatically gained in popularity since 2014 (Durrani, Gotkin, & Laughlin, 2015) and podcasts with a consistent number of episodes over many months indicate an interested audience (Mcclung & Johnson, 2010). Thus, this project leverages podcast data to measure seven types of exercise in the US. The podcasts used in this project were chosen because they are the top exercise podcasts in the US, according to Spotify.

Table   
*Summary of Literature Review Resources by Category*

|  |  |  |
| --- | --- | --- |
| Category | Theoretical Construct | Source |
| COVID-19 Information | COVID-19 timeline | World Health Organization |
| COVID-19 Information | COVID-19 government orders | Chowell |
| COVID-19 Information | COVID-19 government orders | Gostin & Wiley |
| US Behavior | US commercial gym closures | Ramirez-Campillo & Souza |
| US Behavior | US attitudes regarding COVID-19 | Tynan & Howard |
| US Behavior | US population movement | Center for Disease Control |
| US Behavior | A new normal | Roberts & Tehrani |
| US Behavior | Working from home increase | Ahmad |
| US Behavior | Netflix subscription increase | Dias |
| US Exercise | Importance of exercise in the US | Fletcher |
| Podcast Data | Relationship between interest and relevance | Tobarra & Caminero |
| Podcast Data | Podcast popularity | Durrani, Gotkin, & Laughlin |
| Podcast Data | Podcast audience | Mcclung & Johnson |

# Methodology

As stated above, this project’s research focused on answering the following question:

Which types of exercise are more popular in the US post-COVID-19?

To answer this question, a five-step methodology was used:

1. **Data Acquisition and Storage**: According to the literary review conducted for this research project, podcast listening corresponds to interest in a subject and interest corresponds to relevancy. Thus, the primary data source used to answer this question was US-based, exercise-related podcasts.

* To acquire podcast data, this project connected to Spotify’s API with python. To store data acquired from Spotify, this project leveraged a cloud-based data warehouse created using Oracle Database 12c.

1. **Data Exploration**: Each variable in the podcast dataset was explored for data type and distribution. Then, the three most important variables were closely explored: number of episodes, episode description, and episodes per podcast per week.
2. **Data Preparation**: All episodes with missing data were removed. Then, each episode record was labelled with a week, month, and pre-vs-post COVID-19 distinction and each podcast record was labelled with a genre and the average number of episodes per week. Finally, podcasts without enough episodes both pre-COVID-19 and post-COVID-19 were removed from the dataset.
3. **Natural Language Processing**: Each podcast episode description was run through a python natural language processor (library: NLTK) to determine the number of exercise-related terms used. Then, the number of exercise terms per podcast description was calculated.
4. **Two-Sample T-Test for Difference of Means**: With the dataset properly labelled and analyzed, seven separate two-sample t-tests were set up to test changes in seven different types of exercise. Each test used the same podcast dataset and each measured changes between pre-COVID-19 and post-COVID-19. For all t-tests, the null hypothesis was that the popularity of this type of exercise did not change after COVID-19. The alternate hypothesis was that this type of exercise did change post-COVID-19.

# Experimentation and Results

Question: Which types of exercise are more popular in the US post-COVID-19?

## Data Acquisition and Storage

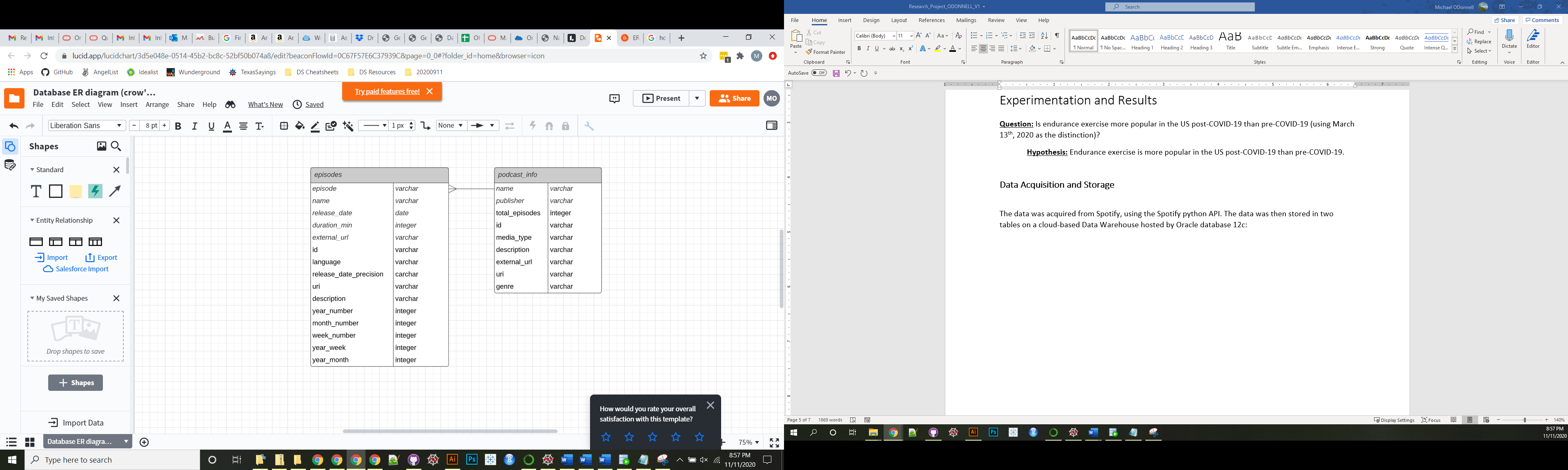
The podcast data was acquired from Spotify using Spotify’s Python API. The data was collected from 47 of the largest US exercise podcasts and totaled 11,447 episodes. More details pertaining to the data collection are found in the chart below:

Table   
*Episodes Collected by Podcast*

|  |  |
| --- | --- |
| Podcast | Episodes Collected |
| 9 to 5 Fitness | 75 |
| Align Podcast | 300 |
| AMRAP Mentality with Jason Khalipa | 50 |
| Another Mother Runner | 500 |
| BarBend Podcast | 125 |
| Ben Greenfield Fitness | 972 |
| Bulletproof Radio | 750 |
| Chasing Excellence | 125 |
| CITIUS MAG Podcast with Chris Chavez | 175 |
| Corpus Animus Podcast | 25 |
| Cultra Trail Running | 100 |
| Froning and Friends | 125 |
| IST CrossFit Podcast | 25 |
| Joe DeFranco's Industrial Strength Show | 250 |
| Kyle Kingsbury Podcast | 175 |
| Mind Pump: Raw Fitness Truth | 1450 |
| Misfit Podcast | 150 |
| Muscle For Life with Mike Matthews | 625 |
| No Meat Athlete Radio | 350 |
| Not Real Runners | 125 |
| On Purpose with Jay Shetty | 175 |
| Pace the Nation | 300 |
| Run Selfie Repeat | 50 |
| Run to the Top Podcast | The Ultimate Guide to Running | 400 |
| RunBuzz Running Podcast | 125 |
| Runners of NYC | 50 |
| Running Lean | 25 |
| Running Things Considered | 25 |
| SHRED CrossFit Podcast | 25 |
| The BibRave Podcast | 225 |
| The Brute Strength Podcast | 25 |
| The Jillian Michaels Show | 500 |
| The Mind Muscle Project | 750 |
| The Not Your Average Runner Podcast | 150 |
| The Refined Savage | 175 |
| The Runner's World Show | 75 |
| The Runners Zone | 25 |
| The Running Pod | 25 |
| The Running Public | 75 |
| The Strength Running Podcast | 150 |
| The WAG Podcast | 75 |
| The WODcast Podcast | 425 |
| Trail Runner Nation | 475 |
| Trail Running Women | 100 |
| TRAINED | 50 |
| Ultrarunnerpodcast.com | 425 |
| WHOOP Podcast | 75 |
| Total | 11447 |

As the data was collected from Spotify, it was stored in two tables on a cloud-based data warehouse hosted by Oracle Database 12c. The structure of the tables is shown below:

Figure   
*Entity Relationship Diagram of Collected Data*



In the “episodes” table, there are 11,447 rows (episodes) and 15 columns. In the “podcast info” table there are 47 rows (podcasts) and nine columns.

## Data Exploration

The episodes table was first explored at a high-level. Since the hypothesis relies on time (pre and post March 13, 2020), the **number of episodes** was broken down by year and episodes pre-COVID-19 and post-COVID-19:

Table   
*Episodes Collected by Year*

|  |  |
| --- | --- |
| Year | Episodes |
| 2020 | 2435 |
| 2019 | 2266 |
| 2018 | 1824 |
| 2017 | 1440 |
| 2016 | 1173 |
| 2015 | 1005 |
| 2014 | 540 |
| 2013 | 385 |
| 2012 | 291 |
| 2011 | 79 |

Table   
*Episodes Collected pre-COVID-19 and post-COVID-19*

|  |  |
| --- | --- |
| Dates | Episodes |
| pre-COVID-19 | 9533 |
| post-COVID-19 | 1914 |

Next, the **duration of podcast episodes** was analyzed, first for overall distribution, then by year (including only years with >= 1000 episodes):

Figure   
*Histogram of Episode Duration in Minutes*

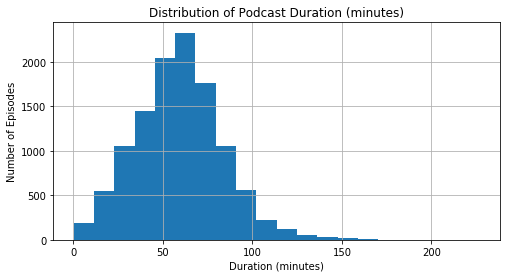
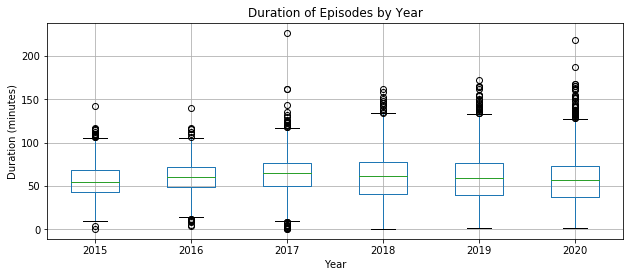
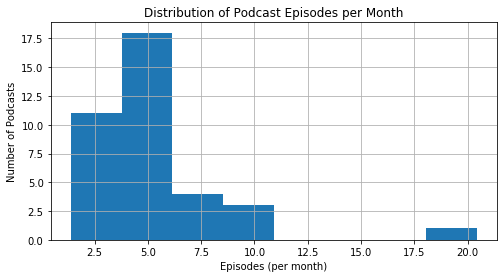


Figure   
*Boxplot of Episode Duration in Minutes by Year*



Finally, the number of **episodes per month by podcast** was analyzed for distribution:

Figure   
*Histogram of Episodes per Month by Podcast*



## Data Preparation and Natural Language Processing

To prepare the data, podcasts were removed that did not have a sufficient number of episodes both pre-COVID-19 and post-COVID-19. The threshold for a sufficient number of episodes was at least one episode per month from January 2020 to October 2020. This threshold filtered out 10 podcasts totaling 975 episodes. This left 37 podcasts totaling 10,472 episodes.

With the final set of 37 podcasts, all 10,472 episodes were run through a natural language processer in python (library: NLTK). The natural language processor counted the number of exercise-related words in each episode for 7 different types of exercise. The types of exercise and exercise-related words are detailed below:

Table   
*Frequency Table of Exercise Related Words*

|  |  |  |
| --- | --- | --- |
| Type of Exercise | Related Word | Occurrences |
| Running | running | 404 |
| run | 150 |
| jogging | 355 |
| jog | 147 |
| Cycling | cycling | 513 |
| cycle | 468 |
| biking | 305 |
| bike | 260 |
| Swimming | swimming | 488 |
| swim | 334 |
| freestyle | 422 |
| breaststroke | 421 |
| butterfly | 342 |
| backstroke | 487 |
| Walking | walking | 556 |
| walk | 402 |
| Weightlifting | weightlifting | 761 |
| lifting | 223 |
| lift | 69 |
| barbell | 425 |
| kettlebell | 571 |
| dumbbell | 423 |
| squat | 227 |
| press | 150 |
| bench | 528 |
| deadlift | 178 |
| Crossfit | WOD | 334 |
| box | 208 |
| amrap | 41 |
| afap | 53 |
| Yoga | yoga | 54 |
| streching | 494 |
| meditation | 209 |

## Two-Sample T-Test for Difference of Means

After Natural Language Processing was run on all 10,472 episode descriptions, the data was prepared to answer the research question: Which types of exercise are more popular in the US post-COVID-19?

To scientifically answer this question, a two-sample t-test was set up for each of the seven types of exercise included in the project: running, cycling, swimming, walking, weightlifting, Crossfit, and yoga.

Each t-test measured the mean of exercise-specific terms used per podcast episode description. Using weightlifting as an example, the mean of weightlifting-related terms per podcast episode description was compared between pre-COVID-19 and post-COVID-19.

Each t-test had the same null and alternative hypothesis:

Null Hypothesis: μpre-COVID exercise-specific terms= μpost-COVID exercise-specific terms

Alternate Hypothesis: μpre-COVID exercise-specific terms≠ μpost-COVID exercise-specific terms

The significance level (α) was 0.05 for all t-tests.

The results of the seven t-tests are presented below:

Table   
*Hypothesis Test Results for each type of Exercise*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Type of Exercise | Mean difference (post-pre) | t-statistic | p-value | significance level (α) | Hypothesis Result | Conclusion |
| Running | 0.142 | 2.043 | 0.041 | 0.05 | Reject the null | More popular |
| Cycling | -0.026 | -3.292 | 0.001 | 0.05 | Reject the null | Less popular |
| Swimming | -0.015 | -2.722 | 0.007 | 0.05 | Reject the null | Less popular |
| Walking | -0.01 | -0.068 | 0.945 | 0.05 | Cannot reject the null | No change |
| Weightlifting | 0.079 | 2.697 | 0.007 | 0.05 | Reject the null | More popular |
| Crossfit | -0.031 | -4.79 | 0.001 | 0.05 | Reject the null | Less popular |
| Yoga | -0.023 | -1.098 | 0.272 | 0.05 | Cannot reject the null | No change |

# Conclusions

This project began with a question: Which types of exercise are most popular in the US post-COVID-19? To measure exercise popularity, a connection was made between podcast episode content and relevancy to podcast listeners. Therefore, 11,447 podcast episode descriptions from 47 major US exercise-related podcasts were acquired.

During the data exploration phase, podcast episodes were divided between pre-COVID-19 and post-COVID-19 episodes. In total, there were 9,522 pre-COVID-19 episodes and 1,914 post-COVID-19 episodes.

During the data preparation phase, 975 podcast episodes were removed because their corresponding podcasts could not be compared between pre-COVID-19 and post-COVID-19.

After the data was explored and prepared, all podcast episode descriptions were run through a natural language processor in python to count the number of words related to each of the following seven types of exercise: running, cycling, swimming, walking, weightlifting, Crossfit, and yoga.

Using the natural language processing results, seven two-sample t-tests were run to compare the means of exercise-related terms used pre-COVID-19 and post-COVID-19 for each of the seven types of exercise. From the two-sample t-tests, it was clear that running and weightlifting became more popular post-COVID-19:

Table   
*Research Conclusions*

|  |  |
| --- | --- |
| Type of Exercise | Conclusion |
| Running | More popular |
| Cycling | Less popular |
| Swimming | Less popular |
| Walking | No change |
| Weightlifting | More popular |
| Crossfit | Less popular |
| Yoga | No change |

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# Appendix with Code

## Data Acquisition

1. # get podcast episodes from a show
2. **def** get\_all\_podcast\_episodes(self, showid, market = 'US'):
3. headers = self.get\_resource\_header()
5. podcast\_name = self.get\_podcast\_info\_by\_id(showid)['name']
6. num\_episodes = self.get\_podcast\_info\_by\_id(showid)['total\_episodes']
8. limit = 25
9. offset = 0
10. num\_runs = num\_episodes//limit
12. episode\_df = pd.DataFrame(columns = ['podcast', 'name','release\_date','duration\_min',
13. 'external\_urls','id', 'language',
14. 'release\_date\_precision', 'uri','description'])
16. **for** i **in** range(num\_runs):
18. endpoint = f"https://api.spotify.com/v1/shows/{showid}/episodes?offset={offset}&limit={limit}&market=US"
19. lookup\_url = f"{endpoint}"
21. r = requests.get(lookup\_url, headers = headers)
22. **if** r.status\_code **not** **in** range(200,299):
23. **return** "somethings wrong..."
25. raw\_json = r.json()


29. **for** i **in** range(limit):
30. # create a dict with the data
31. temp\_dict = {'podcast': podcast\_name,
32. 'name': raw\_json['items'][i]['name'],
33. 'release\_date': raw\_json['items'][i]['release\_date'],
34. 'duration\_min': round((raw\_json['items'][i]['duration\_ms'])/60000,2),
35. 'external\_urls': raw\_json['items'][i]['external\_urls'],
36. 'id': raw\_json['items'][i]['id'],
37. 'language': raw\_json['items'][i]['language'],
38. 'release\_date\_precision': raw\_json['items'][i]['release\_date\_precision'],
39. 'uri': raw\_json['items'][i]['uri'],
40. 'description': raw\_json['items'][i]['description']}
42. df = pd.DataFrame(temp\_dict, columns = ['podcast','name','release\_date','duration\_min',
43. 'external\_urls','id', 'language',
44. 'release\_date\_precision', 'uri','description'])
45. episode\_df = episode\_df.append(df)
47. offset = offset + limit
49. episode\_df = episode\_df.reset\_index(drop=True)
50. **return** episode\_df

## Data Exploration

1. # create histogram of episode duration
2. plt.figure(figsize=(8,4))
4. plt.hist(df['duration\_min'], bins = 20)
5. plt.xlabel("Duration (minutes)")
6. plt.ylabel("Number of Episodes")
7. plt.title("Distribution of Podcast Duration (minutes)")
8. plt.grid(True)
10. plt.show()
12. # create boxplot of episode duration by year
13. df[df['year\_number']>2014].boxplot(by='year\_number',
14. column=['duration\_min'],
15. grid=True,
16. figsize = (10,4))
17. plt.title("Duration of Episodes by Year")
18. plt.suptitle("")
19. plt.ylabel("Duration (minutes)")
20. plt.xlabel("Year")
21. plt.show()

## Data Preparation

1. # add year, month, and week numbers to dataframe
2. df['year\_number'] = pd.to\_datetime(df['release\_date']).dt.year
3. df['month\_number'] = pd.to\_datetime(df['release\_date']).dt.month
4. df['week\_number'] = pd.to\_datetime(df['release\_date']).dt.week
5. df['year\_week'] = df['year\_number'].map(str) + df['week\_number'].map(str)
6. df['year\_month'] = df['year\_number'].map(str) + df['month\_number'].map(str)
8. **for** i **in** df['podcast'].unique():
9. temp\_df = df[df['podcast']==i]
10. **print**(i, "|", round(len(temp\_df)/len(temp\_df['year\_month'].unique()),2))

## Natural Language Processing and Two-Sample T-Test

1. # function to setup hypothesis test for podcast descriptions pre vs post COVID
2. **def** podcast\_description\_hypothesis\_test(csv, list\_of\_words, alpha, title = "hypothesis test"):
4. # first, read in the csv
5. # 'data/final\_datasets/relevant\_episode\_data\_v2.csv'
6. episode\_desc\_df = read\_episode\_descriptions(csv)
7. preCOVID\_episode\_desc\_df = episode\_desc\_df[pd.to\_datetime(episode\_desc\_df['release\_date']) < '2020-03-13']
8. postCOVID\_episode\_desc\_df = episode\_desc\_df[pd.to\_datetime(episode\_desc\_df['release\_date']) >= '2020-03-13']
10. # format description column for tokenization
11. desc\_df = create\_episode\_df(episode\_desc\_df)
12. preCOVID\_df = create\_episode\_df(preCOVID\_episode\_desc\_df)
13. postCOVID\_df = create\_episode\_df(postCOVID\_episode\_desc\_df)
15. # tokenize all 3 dataframes
16. episode\_tokens = tokenize\_descriptions(desc\_df)
17. preCOVID\_tokens = tokenize\_descriptions(preCOVID\_df)
18. postCOVID\_tokens = tokenize\_descriptions(postCOVID\_df)
20. # create final dataframes for analyses
21. episode\_dataset = pd.DataFrame(episode\_tokens[1])
22. preCOVID\_dataset = pd.DataFrame(preCOVID\_tokens[1])
23. postCOVID\_dataset = pd.DataFrame(postCOVID\_tokens[1])
25. # add number of exercise terms to each row in above datasets
26. episodes\_terms = []
27. **for** i **in** range(len(episode\_dataset)):
28. episodes\_terms.append(count\_terms(episode\_dataset['description'][i], list\_of\_words))
29. episode\_dataset['number\_of\_words'] = episodes\_terms
31. preCOVID\_terms = []
32. **for** i **in** range(len(preCOVID\_dataset)):
33. preCOVID\_terms.append(count\_terms(preCOVID\_dataset['description'][i], list\_of\_words))
34. preCOVID\_dataset['number\_of\_words'] = preCOVID\_terms
36. postCOVID\_terms = []
37. **for** i **in** range(len(postCOVID\_dataset)):
38. postCOVID\_terms.append(count\_terms(postCOVID\_dataset['description'][i], list\_of\_words))
39. postCOVID\_dataset['number\_of\_words'] = postCOVID\_terms
41. # find mean, standard deviation, and count of pre-COVID-19 exercise terms
42. preCOVID\_mean = preCOVID\_dataset['number\_of\_words'].mean()
43. preCOVID\_sd = preCOVID\_dataset['number\_of\_words'].std()
44. preCOVID\_episodes = len(preCOVID\_dataset['number\_of\_words'])
46. # find mean, standard deviation, and count of post-COVID-19 exercise terms
47. postCOVID\_mean = postCOVID\_dataset['number\_of\_words'].mean()
48. postCOVID\_sd = postCOVID\_dataset['number\_of\_words'].std()
49. postCOVID\_episodes = len(postCOVID\_dataset['number\_of\_words'])
51. # use scipy to get test statistic and p-value
52. hyp\_test = stats.ttest\_ind(postCOVID\_dataset['number\_of\_words'],preCOVID\_dataset['number\_of\_words'], equal\_var=False)
53. t\_statistic = hyp\_test[0]
54. p\_value = hyp\_test[1]
56. # print findings
57. **print**("words tested:", list\_of\_words)
58. **print**("variance of postCOVID:", round(postCOVID\_dataset['number\_of\_words'].var(), 2))
59. **print**("variance of preCOVID:", round(preCOVID\_dataset['number\_of\_words'].var(), 2))
60. **print**("difference in means = ", round((postCOVID\_mean-preCOVID\_mean), 3))
61. **print**("t = ", round(t\_statistic, 3))
62. **print**("p = ", round(p\_value, 3))
63. **print**("alpha = ", str(alpha))
64. **if** stats.ttest\_ind(postCOVID\_dataset['number\_of\_words'],preCOVID\_dataset['number\_of\_words'], equal\_var=False)[1] < alpha:
65. **print**("Hypothesis result: REJECT the null hypothesis")
66. **else**:
67. **print**("Hypothesis result: cannot reject the null hypothesis")
69. # export dataset
70. postCOVID\_dataset['post\_COVID'] = 1
71. preCOVID\_dataset['post\_COVID'] = 0
72. df = preCOVID\_dataset
73. df = preCOVID\_dataset.append(postCOVID\_dataset)
74. df.to\_csv(f"{title}\_data.csv")