



INFLUENCES ON RUNNING PACE

Visualization Testing

Nicole McCarthy
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Introduction

The purpose of this project is to create and evaluate the effectiveness of visualizations of the author's running pace and confounding factors. Major factors include previous exercise (creating fatigue), distance, elevation changes, and weather. The most important weather factors include temperature and humidity (or dewpoint), but wind speed was also included in the study. With effective visualizations, the author and other runners in similar environments may learn more about how to adjust pace for different kinds of runs in different weather conditions.

Data

The running and fitness data was retrieved from the author's Garmin app and was recorded on a Garmin Forerunner 265s. All data that was not recorded in Houston, Texas or of running were not included in the dataset to increase consistency. Furthermore, weather data was provided by Weather Underground (retrieved July 23, 2025). The data includes the following:

- Time
 - Date
 - Time
- Activity Information
 - Distance (miles)
 - Duration (hours: minutes: seconds)
 - Average Heart Rate (bpm)
 - Elevation Gain (feet)
- Exercise Load Information
 - Acute Daily Training Load
 - Chronic Daily Training Load
- Daily Weather
 - Average Temperature (degrees Fahrenheit)
 - Average Humidity (percent)
 - Average Wind Speed (mph)

The time, activity information, and daily weather columns are self-explanatory. The exercise load columns are meant to estimate body fatigue from exercise, which can affect running performance. The Acute Daily Training Load is a weighted sum of the last seven days'

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Excess Post-exercise Oxygen Consumption (EPOC). After exercise, humans tend to consume more exercise for several hours than they otherwise would. Therefore, measuring the EPOC is a good indicator of how stressful an activity was on one's body. The higher it is, the more stress there is on the body. The Chronic Daily Training Load is the same as the Acute version, except it takes into account the last twenty-eight days, rather than just the last seven (Garmin, 2025).

Note there are a few anomalies in the data that may affect the relationships seen. The first is that the author was training for her first half marathon from before the data starts to January 19, 2025. Second, the author and runner had surgery on February 19, 2025, from which she had to recover and then try to get back running strength afterwards. Finally, the author/runner began training for her first marathon in May.

Goals/Tasks

There are three goals for this project. The visualizations should provide insight into how exercise load/fatigue, the run parameters (distance, elevation changes, and time of day), and weather conditions (temperature and humidity) affect running pace. This is to help runners determine whether their pace is getting faster over time, despite other things that may be slowing them down.

Methodology

Three images that are very similar were created relating to the three areas of exploration: exercise load, environmental factors, and run parameters. For each visualization the pace quantile was set on the y-axis. This is because it is the dependent variable in the question. Additionally, the pace is represented in quantiles rather than absolute values because the absolute scale was not friendly to teasing out larger relationships.

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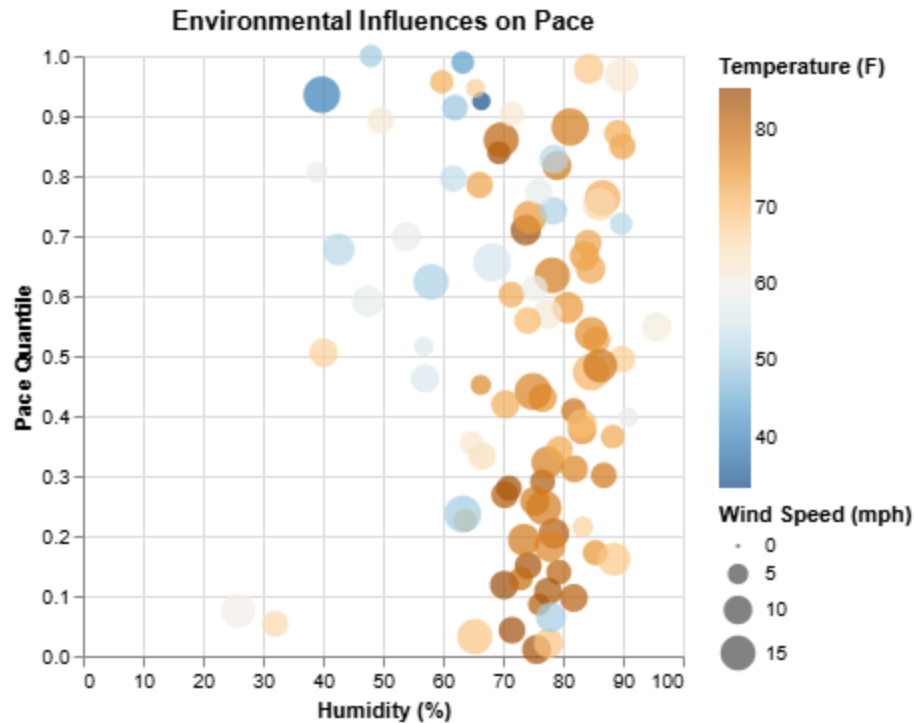


Figure 1. First Visualization for Testing: Environmental Influences

The first image created visualized the relationship between running pace quantile and environmental factors, including temperature, humidity, and wind speed (Figure 1). Humidity was placed on the x-axis and temperature was shown with a diverging color scale. These two factors were the most important to stand out, so they got the more effective representation methods. Wind speed, a lesser factor, was shown by the size of the marks.

The visualization for exercise load has Chronic Training Load on the x-axis and Acute Training Load is encoded as a single hue, red (Figure 2). This is because chronic load has a larger, more sustained spread from data point to data point, whereas the acute load is much more specific to each run.

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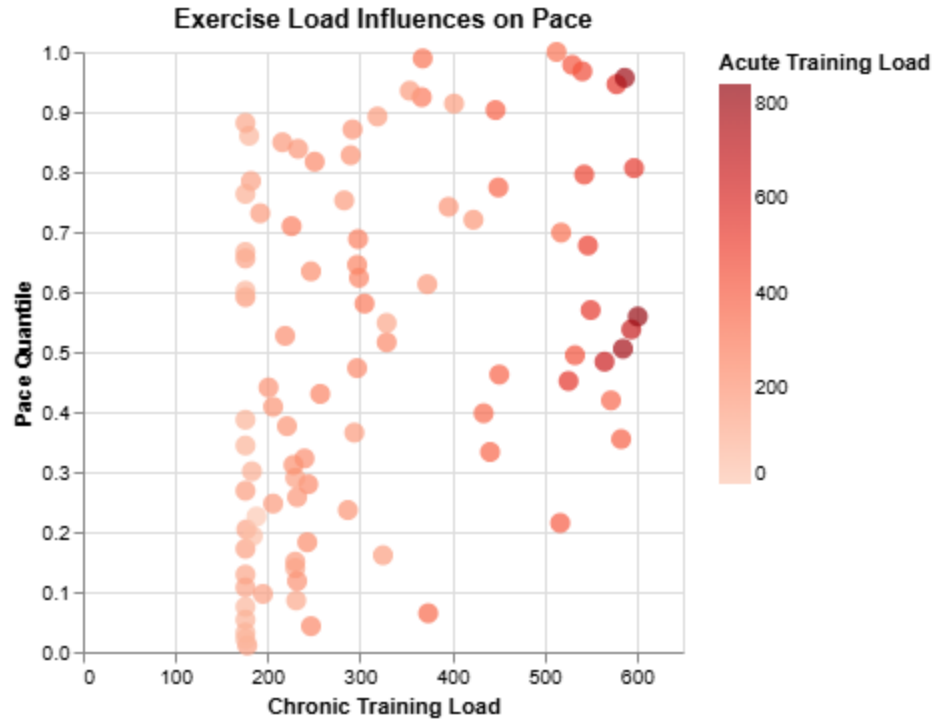


Figure 2. Second Visualization for Testing: Exercise Load Influences

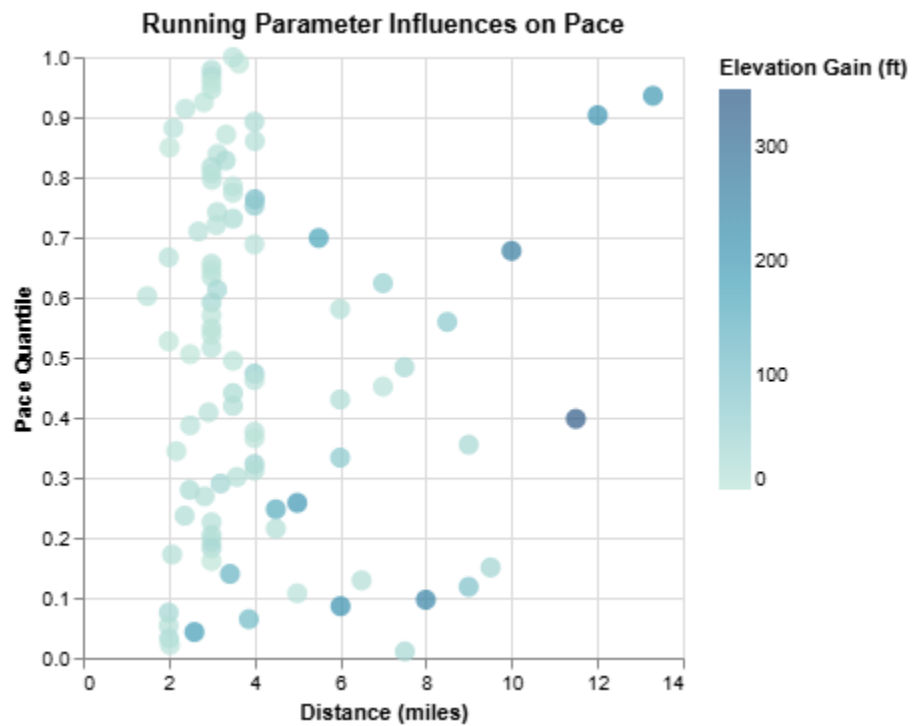


Figure 3. Third Visualization for Testing: Running Parameters

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Running Parameters were visualized with distance (miles) on the x-axis and elevation gain (feet) in a single hue range, blue (Figure 3). Distance was the most important parameter, so it was encoded with the most obvious item, position. Meanwhile, elevation does not change much and, therefore, did not have much to add. However, the coloring differences are noticeable when necessary.

Discussion of Evaluation

Three testers were chosen due to their background as casual runners who track their runs either on a watch or through Strava on their phone. They varied in age, gender, and years of run experience. Each volunteer was emailed the images and told the data came from Garmin watch run data for a few months of exercise. An emphasis on first impressions was made and they were told to respond with a bullet list of observations. Possible observations for each graph are as follows:

Environmental Influences:

- Most runs are in high humidity and high temperature
- Higher temperatures have a weak link to reduced pace
- Higher wind speed might be related to faster paces
- Lower humidity may help with higher pace.

Exercise Load

- Chronic and acute training loads are positively correlated
- Chronic and acute training loads are weakly correlated with pace
- Most runs have a low chronic and low acute training load

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- Chronic training load never goes below 150

Run Parameters

- Most frequent distances are 2-4 miles, with little elevation gain
- Elevation gain is not strongly correlated with pace
- Distances over 10 miles have faster paces and higher elevation gain
- The half marathon distance is one of the fastest paces in the entire data set

The strongest observation by far was that chronic and acute training loads were positively correlated with pace quantile. It was also noted by at least one tester that chronic and acute loads were correlated with each other, higher temperatures reduced pace, and elevation gain was not strongly correlated with pace. Areas of confusion included whether wind or humidity affected pace, and if distance had an effect.

Overall, position seemed to be the most important indicator used by the testers. Color and size were not popular and noted as somewhat confusing. However, the largest area of improvement was on axis labeling. None of the testers knew if a higher pace quantile meant a faster or slower pace. One tester suggested using a percentage instead.

Additionally, two of the testers mentioned they were unsure of how to interpret Acute/Chronic Training Load because they did not know what exactly that meant or what the units would be. One person suggested replacing that with miles per week (MPW), which is a popular running measure of intensity of training. Finally, viewers were also interested in splitting elevation gain into another graph with it on an axis for clearer understanding. One tester also mentioned that it might be useful to keep pace on the x-axis instead of the y-axis.

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The testers showed interest in having a little more assistance from the visualization in making their conclusions. For instance, one asked for a trend line to be added and another suggested the use of histograms or other types of plots that might be easier to interpret. All three started by saying that trends were not immediately popping out at them, which seemed to be frustrating. None of them questioned the data itself and figured it must be an issue with the layout of the visualization that they could not immediately tease out trends.

Conclusion

This experiment has provided three key insights into creating visualizations from real data for users:

1. Users expect to see trends right away. They do not necessarily want to look deeply for new insights. This may be because popular running apps like Strava make visualizations that always offer immediately clear trend data upon first glance.
2. Users need easy to interpret units. Calculated exercise science units that are not well-known among the public are not easily interpreted and usable. Chronic and Acute Training Loads are not useful information. Pace must be more obviously directional.
3. Color and size are not easily interpreted. Position is the most useful encoding. If color and position are used, it should simply be in addition to position, not for an entirely new variable. In general, more graphs that are simple are better than fewer but more complicated graphs.

Future work on this project should include adjustments based on the conclusions listed above. This means not relying on data to speak for itself, but attempting to make trends more obvious, even if they are weak. Additionally, the interpretability of units is important and should

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be adjusted. Finally, more graphs should be made so that trends are easier to see using the position encoding, rather than stacking different variables with different encodings.

References

Garmin. (2025). “What Is the Acute and Chronic Load Feature of My Device?” *Garmin*.

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