Does running cadence affect heart rate?

Introduction

The heart is one of the most complex organs in live organisms, ergo heart rate signals are complex too. The scientists believe that heart rate depends on sleep, weather conditions, level of stress, current activity, age, having cardiovascular disease and much more. Notwithstanding this research focuses on the hidden factor that affects pulse rate during cyclic activities: running cadence. The cadence is often defined as the total number of steps per minute and is measured in steps per minute (SPM). In any cyclic sport there is a point estimate for the optimal cadence. For instance: 180 in running, 90 in cycling, 50-60 in swimming, etc. The goal is to find the optimal cadence for Taras Svystun. The aim of this project is to study the effect of the aforementioned factor on pulse rate.

Data description

Measurements

All data was collected from 27 runs during this semester from my Garmin sport watch. During running activities my watch records the following:

- Current speed
- Current Heart Rate
- Current Cadence
- Current Altitude
- Elevation gain
- Time spent etc.

The main question that may arise is: what about the measurement accuracy?

The speed is calculated using all satellite systems + multi-band. All satellite systems means that the watch is using not only GPS signals, but also GLONASS, GALILEO etc. Multi-band means improved tracking and accuracy in more challenging environments when the signals are being reflected off walls or canyons and in cases where the signal is blocked, like under trees or forest canopy.

Heart Rate is measured from a garmin optical heart rate that gauges activity intensity as well as heart rate variability. It also tracks underwater without a heart rate strap. Compared with the readings of an

electrocardiogram measurement, the mean percentage error of the Garmin devices was remarkably low: 1.16-1.39%.

The information about the exact algorithm for calculating the cadence is unavailable, but it is believed that Garmin uses accelerometer data to calculate the cadence.

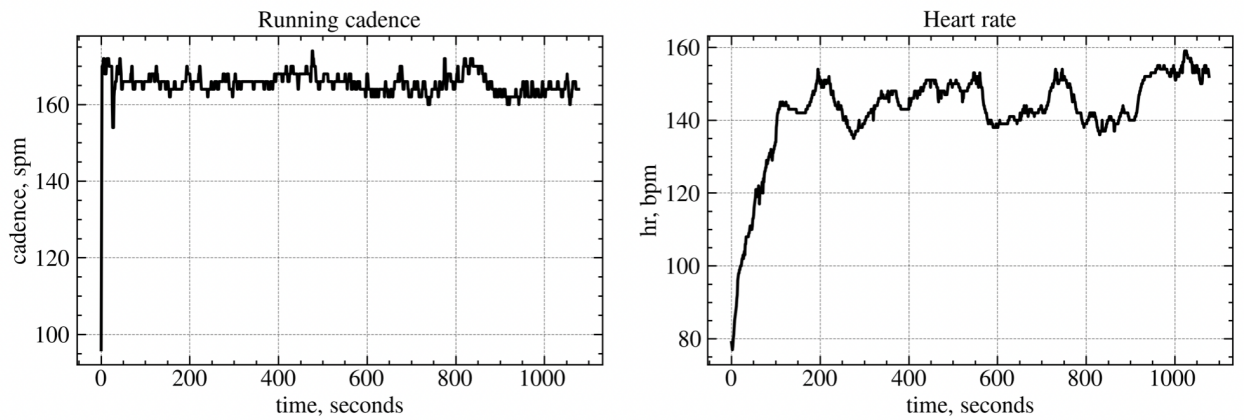
Since all other metrics are not used in the research, they are not further described.

Running activities description

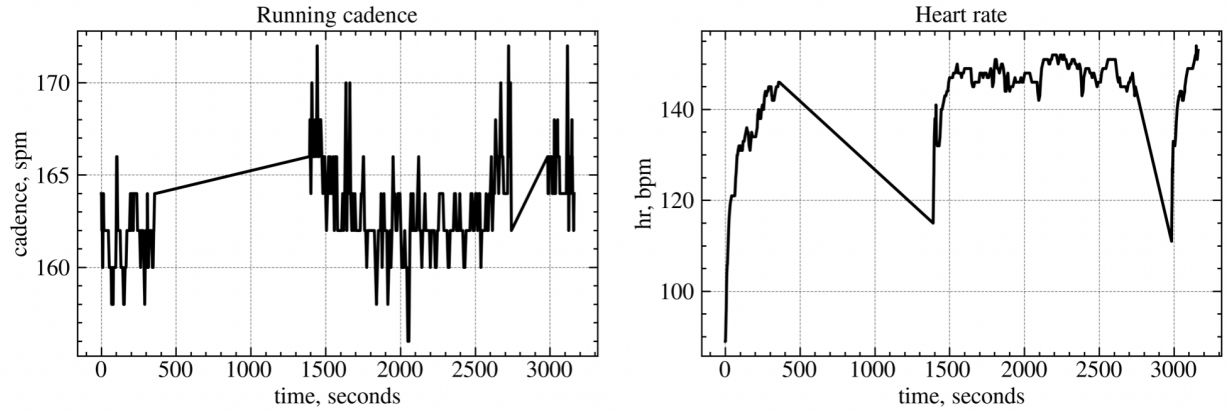
27 runs are as different as possible. There are several short runs, covering the distance 2-5 km. Most of the runs are my casual runs with HR in second or third zones (130 - 155 bpm) and near 30-60 mins long. There are also two trail runs in the mountains with huge elevation gain and 26 and 40 km distance covered.

Problems with measurements

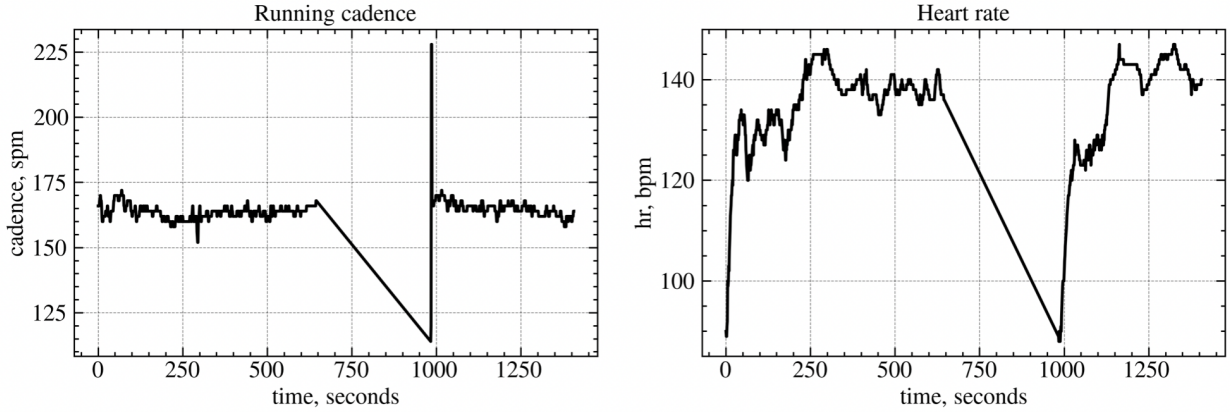
The main drawback of Garmin recordings is not equal distance in time between trackpoints. What I mean by this is that the HR is recorded at seconds 1, 3, 7, 8 and 10. The way I approached the given problem is by using interpolation, which was covered in one of the Laboratory works during the semester.
With most of the runs the discussed method worked fine.



Some of the runs had several minutes of empty trackpoints. I guess those are Garmin device problems.



But there were a couple of cases where the mentioned approach failed. But the problems are with garmin glitches, not interpolation issues.



I also noticed that the way I calculated average HR or average Cadence yielded a bit different numbers that are provided by Garmin. I reckon Garmin developers ignore the time periods with missing information. That is one of the approaches, but I think that mine is better. In simple words, imagine a HR signal: [100, 160, 160, 100] and the times recorded are: [0, 1, 9, 10]. I guess Garmin algorithms just take the average of HR signals which yields 130. But it looks from the data, that the actual analogue HR signal has average slightly larger than 130, since most of the time it was closer to 160.

Cadence – HR analysis

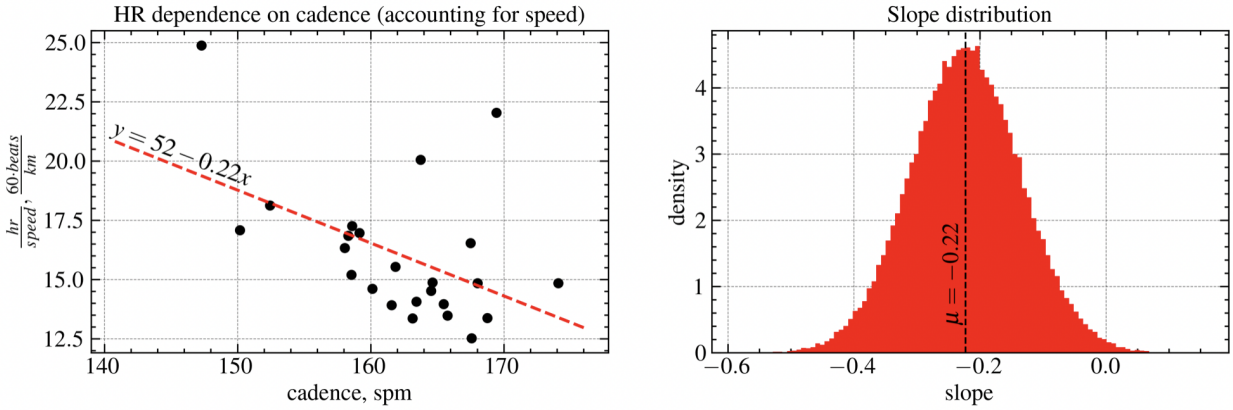
The problem description: is there any evidence that higher cadence descreses HR?

Before any analysis, I need to disregard two trail runs at mountains, since 30% of the activity was spent walking, not running.

At first, I ran simple linear regression on HR as regressand and Cadence as regressor. I got the opposite results: higher cadence leads to higher HR (positive trend). But there's a mistake, since on average

running faster makes me move my legs faster, i.e. higher cadence. In other words, the researcher ought to account for speed to isolate only HR and cadence relationships.

So then instead of considering pure HR, I considered a variable which is the ratio between HR and current speed. Intuitively, the higher the speed, the higher the Heart Rate. So to balance them, the simplest thing one can do is to take their ratio. And here are the results, which I obtained.



The left scatterplot reveals the relationship between HR and cadence, taking speed into account. The y-axis and HR / speed in general is not a very explainable variable and I will not focus on that. But the plot shows that keeping the speed constant at 10 km/h, increasing your cadence by 10 spm will decrease the HR by 22 beats per minute. One may argue that a sample of size 24 is not enough and may lead to wrong results. I agree with that, since there is no clear negative correlation of HR and cadence. But considering the t-value of slope coefficient, one can see that p-value of slope being equal to zero is less than 0.02, which is more than enough in this particular research to reject the null hypothesis about no relationship between HR and Cadence.

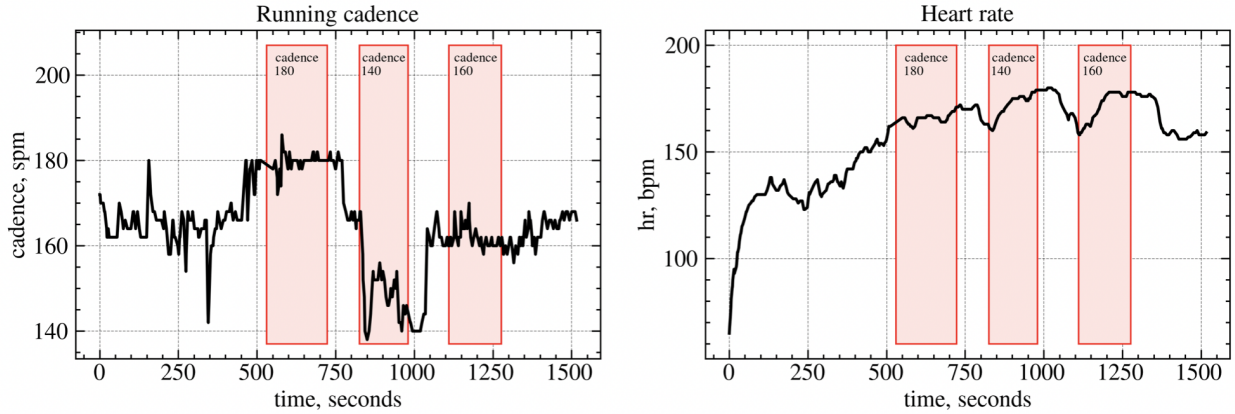
On the right histogram one can see the distribution of the slope of HR regressing on Cadence. Just from the plot it is very unlikely that I obtained the negative slope by accident. The area under the bell curve which corresponds to values larger than 0 is negligibly small.

Special case analysis

This section does not pretend to be a serious analysis, because I didn't manage to follow the plan. The idea was to record several runs, where I am intentionally running with target Cadence and then to compare the HR. But I only managed to record a single run. Still it yields interesting results.

The experiment was as follows: decide on random the sequence of 140, 160 and 180 cadence. Then run with a constant pace changing the cadence. Then compare the HR. On the plot below it is easy to recognize that the first session I tried to run with 180 spm cadence. The average pace was 4:39 minutes

per km. The second session the target cadence was 140 spm and the pace was 4:40 mins/km. And finally in the last session I ran with 160 spm and the pace was 4:38 mins/km.



I did 1-2 mins rest between each session, but still the HR graph shows that HR during the first 180 spm interval is lower than during the other two. But still I obtained a simple and expected outcome: running with a low 140 spm cadence increased my HR by 5 bpm.

Conclusion

The human organism is a very complex system and many things depend on a lot of different factors. This research found evidence that indeed running cadence may affect Heart Rate. Thereby increasing the Cadence just by a few spm leads to lower HR, assuming constant speed.

One may want to improve the analysis. I recommend considering at least a hundred runs with the same surface, elevation, physical and mental form.

Code

The primary notebook with the Python code is here: https://github.com/taras-svystun/Does_running_cadence_affect_HR/blob/main/Svystun_final_project.ipynb.

In that repo one can also find additional information and all the data used.