UNIVERSITY OF CAPE TOWN

STA5071Z

SIMULATION AND OPTIMIZATION

Road Running: Social Influence and Group Dynamics

Author:
Roger Bukuru

Student Number:
BKRROG001

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Contents

1   Introduction

This simulation study is designed to investigate the impact of various social dynamics on the performance of non-professional runners during road running events. Specifically, it seeks to compare the effectiveness of group running versus solo running under the influences of several key factors: race distance, weather conditions, the presence of external spectators, and the individual social inclinations of the runners. The research aims to assess how these factors affect the performance differences between group and solo runners and to explore the sustainability of running groups under varying conditions. The repository of this study is available at https://github.com/rogerbukuru/Road-Running-Social-Influence-and-Group-Dynamics

2   Model

Figure 1: Agent-Based Social Dynamics Model

3   Experiments and Results

The experiments were conducted over four running distances: short distances of 5km and 10km, a half marathon distance of 21 km, and a full marathon distance of 42.2km. Each tick within the experiment represents a second in time. For each

experiment, runners are split into either being part of a group or solo runners; for simplicity, we split this equally, but it can be split otherwise for other instances. Each experiment consisted of 20 runners and, where applicable, 50 specators cheering. For each race distance, we evaluated the performance of group runners against solo runners under both dry and wet conditions. For added realism, each runner has a level of endurance, motivation and social-susceptibility. For each experiment, the endurance and motivation factors start at 1 and decrease gradually; these factors ultimately influence a runner's speed generated from a normal distribution of global amateur run speeds ranging from 4.28 m/km to 8.25 m/km. Furthermore, during each experiment, each runner has varying degrees of social susceptibility generated from a normal distribution. Runners with higher susceptibility levels, i.e., those greater than 0.5, are negatively influenced when they have either dropped out of a group or are allotted to run solo. In the experiments with spectators, they were more positively influenced by fan cheering compared to runners with lower social susceptibility. These influences are encompassed in their motivation levels, which ultimately affect their endurance and, finally, their speed, which will ultimately contribute to a runner's finish time. For robustness, 100 simulations were executed for each race distance under each experiment. As both group and solo runners consist of runners bearing varying characteristics in terms of their social susceptibility, we also evaluated their performance between being in a group or solo. For each experiment, a t-test was performed to evaluate if any observed differences were statistically significant. Take note that the t-statistic is the difference between group-runner performance metrics and solo-runner performance metrics, i.e., a negative value means that group runners outperformed the solo runners. Finally, for each experiment, we also analysed group sustainability across the various distances, by averaging the number of groups that have 5 or more members, i.e., 50% or more, at the end of each simulation and representing that as a percentage, so a figure of 70% means that 70% of the simulations had 5 or more members that maintained their group membership over the course of the event. Group membership is maintained if one runs within a group for at least 50% of the distance.

3.1 Experiment 1: Dry weather group runners vs solo runners and no spectators

Experiment 1 was setup so that there were no spectators and under dry conditions. The experiment consisted of 10 runners starting in a group and another 10 starting as solo runners. The aim of the experiment was to assess if there was a difference between group and solo runner performance given good running weather conditions in the absence of external observers influencing the runners. Reviewing Figure 2, but specifically focusing on the 5km distance, we observed similar performance across

solo and group runners, with the following notable differences: group runner speeds are concentrated in a broader range, which suggests variabililty in performance; they peaked at an average faster speed but also peaked at the slowest speed. In general, speed performance across groups and solo runners seems to be very similar. With regards to finish time and remaining focused on the 5km race, Figure 3 shows that solo and group runners had fairly similar finish times; however, group runners generally performed better, as across 100 simulations they outperformed solo runners in 35 simulations. To assess whether these differences were statistically significant, we performed a T-test, and this is shown in Table 1. Reviewing the results, we found that for both average speed and finish times, the differences between group runners and solo-runners were not significant for the 5km and 10km race events, indicating running in either setup had no overall statistical significance on one's performance. Table 1 also indicates that the performance of socially susceptible runners, whether they are running in a group or solo, had no impact on the 5km and 10km race events.

As we increased the race distance to 21km and 42.2km, we observed something important in Figure 2. We noted speeds of 0 m/km for group runners across a number of simulations; these are the results of the initial group breaking as the race proceeds to the point that the group is of no existence at the end of the race. We measure the sustainability of a group based on whether runners were able to stick together for at least 50% of the race. In Table 2, we note that the full marathon has the poorest group sustainability. Finally, beyond the 10 km, we note that there is in fact a statistically significant difference in performance across both average speed and average finish time, as well as across both socially susceptible runners running in a group or solo, as shown in Table 1, and given that the t-statistic is negative for these tests, we confirm that group runners outperformed solo runners.

3.2   Experiment 2: Dry weather group runners vs solo runners with spectators

This experiment maintained the previous weather conditions with the introduction of spectators. Spectators are set to be cheering, and for realism, their cheering levels periodically increase and decrease, therefore fostering various energy levels amongst the crowd. The cheering effects runner motivation levels, which affect endurance, and endurance effects speed, which contributes to runner performance. The cheering effects are averaged, and a proportion of the average is added to the runners motivation. If a runner is high in social susceptibility, i.e., > 0.5, the proportion is slightly larger compared to that added to runners with low levels of social susceptibility, i.e., $<= 0.5$. The experiment's goal is to evaluate the performance of group and solo runners in the presence of external motivational factors. Along with reviewing the general performance of group and solo runners, we specifically evaluated how

socially susceptible runners affect the performance of these categories in the presence of a positive social factor in the form of crowd cheering. Reviewing Figure 4, we note a marginal speed improvement from the first experiment across the group and solo runners. Group sustainability decreased from the 10km event to the full marathon, with a 6% decrease at the full marathon, as depicted in Table 4. Finally, as per the first experiment, Table 3 shows us that performance is only significantly different across group and solo runners over the longer half- and full-marathon distances; this also includes performance for socially susceptible runners in a group and solo socially susceptible runners. As with experiment 1, we again observed negative t-statistic values, indicating that the observed statistical significance indicates that group runners outperformed solo runners at the half and full marathon race events.

3.3   Experiment 3: Wet weather group runners vs solo runners and no spectators

For experiment 3, we removed the spectators and changed the weather condition from dry to wet. To capture the difficulties of running in wet weather, we increased the rate of decrease in motivation levels by doubling the decrease rate compared to running in dry weather. Given there are no spectators, there are no crowd influences to cheer the runners. The experiment, much like with experiment 1, aims to evaluate group and solo runner performance, social susceptibility performance in group and solo settings, and finally group sustainability over the course of the race event, but this time under wet weather conditions. The first notable difference we observed under this experiment compared to experiments 1 and 2 is the general decrease in speed performance, with runners potentially attaining a pace as slow as 9.00 m/km for the 5km event and times as long as 90 minutes (1 hours and 30 minutes) for the 10km event; this is depicted in Figures 6 (average speeds) and Figures 7 (average finish time). The following notable distinction is that group versus solo runner performance differences are visible from the 10 km race event to the full marathon, as shown in group runner speed performance in figure 6 and supported by the t-test results in table 5. Socially susceptible runners also showed statistically significant differences when running in a group versus solo in the 10km event right up to the full marathon and not just from the 21km as with the previous 2 experiments. These key outcomes indicate that under more strenuous conditions, the difference in performance between group and solo runners is significant even from a shorter distance, and the results show that group runners generally outperformed solo runners under these conditions across the various race events. In Table 6, we do, however, note a significant drop in group sustainability for the half marathon event, while the rest had marginal changes.

3.4   Experiment 4: Wet weather group runners vs solo runners with spectators

The final experiment maintains the wet running conditions but introduces spectators that can cheer runners and hence have an influence on their motivation levels. The aim was to evaluate, under wet running conditions, what effect external motivating factors, i.e., cheering fans, have on group and solo runners performance, as well as their effects on socially susceptible runners and overall group sustainability. Reviewing the average speed performance in Figure 9, we observed improvements in group average speeds, as group runners generally outperformed solo runners. Group sustainability across the 100 simulations decreased, with a noteable decrease at the full marathon from 10% sustainability in experiment 3 to 3% in experiment 4. In light of finishing times, where groups were sustained at 5km, 10km, and 21km, group runners generally had better performance. In experiment 3, we observed a statistically significant difference for each test from the 10km to the 42.2km event, however, for this experiment, as shown in table 7 we observed that there was a statistically significant difference for socially susceptible runners at the 10km event with regards to the average speed, which says that spectators had no impact on these runners speed performance for the 10km race event. However, the general statistical significance observed in experiment 3 was maintained in experiment 4, with group runners outperforming solo runners from the 10km race event right through the full marathon.

4   Discussion and Conclusion

The results show that there are in fact performance differences between running in a group and running solo; the differences are more pronounced in longer race events, in this case the half (21 km) and full (42.2 km) marathon events. We observed from experiments 1 to 4 that irrespective of the weather conditions, individual social susceptibility, spectator support, or not, group runners outperformed solo runners at these marathon events. This underscores the psychological aspects of social influence during these events, as they require greater levels of endurance, which are aided by the encouragement or presence of others to enhance or sustain performance.

Runners with higher social susceptibility demonstrated a tendency to perform better in groups, further enforcing the positive psychological aspects of social influence, especially during marathon events. Across experiments 1 to 4 we noted that weather conditions played a crucial role in affecting runner performance, with wet conditions generally leading to a decrease in runner performance both from a speed and time perspective. The difficulties of running in wet conditions were further highlighted when we observed that group runners outperformed solo runners for the shorter

10km, whereas this was not the case in dry conditions. This further demonstrated the observed positive effects of social influence when increased levels of motivation or endurance are required.

In light of group dynamics and sustainability, we observed that group cohesion significantly deteriorates over longer distances, particularly in marathon events. This could be attributed to an inbalance in group member motivation levels as the race grows, which ultimately effects endurance and, as a result, a decrease in speed, which could lead to an individual falling out of the group due to their inability to keep up for an extended period.

The statistical analysis provided through T-tests offers a scientific grounding to these observations, showing significant performance benefits for groups running in specific settings. However, for the model to be more robust, a couple of other real-world scenarios could be considered in further studies to make the simulation more robust. Some considerations could include more complex weather patterns, e.g., wet and windy, and varying levels of spectator cheering that dynamically change throughout the race. Furthermore, we could consider other social aspects such as more diverse group compositions, the effects of mixed-gender groups, and more granular measurements of social interactions within groups to better understand the mechanisms through which social dynamics directly influence performance.

5   Appendix

5.1   Experiment 1: Dry weather group runners vs solo runners and no spectators

Race Event	Test	Statistics	P-Value
5km	Average Speed	-0.398612	0.690671
	Average Finish Time	-0.565349	0.572536
	Socially Susceptible Average Speed	-0.959931	0.338277
	Socially Susceptible Average Finish Time	-1.111131	0.267860
10km	Average Speed	0.584951	0.559274
	Average Finish Time	0.135316	0.892508
	Socially Susceptible Average Speed	-0.923352	0.357534
	Socially Susceptible Average Finish Time	-0.918281	0.360170
21km	Average Speed	-4.918409	2.519364e-06
	Average Finish Time	-3.940346	1.483717e-04
	Socially Susceptible Average Speed	-8.206732	1.914328e-13
	Socially Susceptible Average Finish Time	-6.719984	1.070091e-09
42.2km	Average Speed	-11.069637	3.039556e-07
	Average Finish Time	-11.068090	3.322190e-07
	Socially Susceptible Average Speed	-15.389143	8.546773e-14
	Socially Susceptible Average Finish Time	-15.365261	1.032729e-13

Table 1: Statistical Tests Results for Different Race Events

Race Event	Group Sustainability %
5km	100%
10km	96%
21.1km	65%
42.2km	17%

Table 2: Group Sustainability at end of Race Event

5.1.1   Average Speed Performance
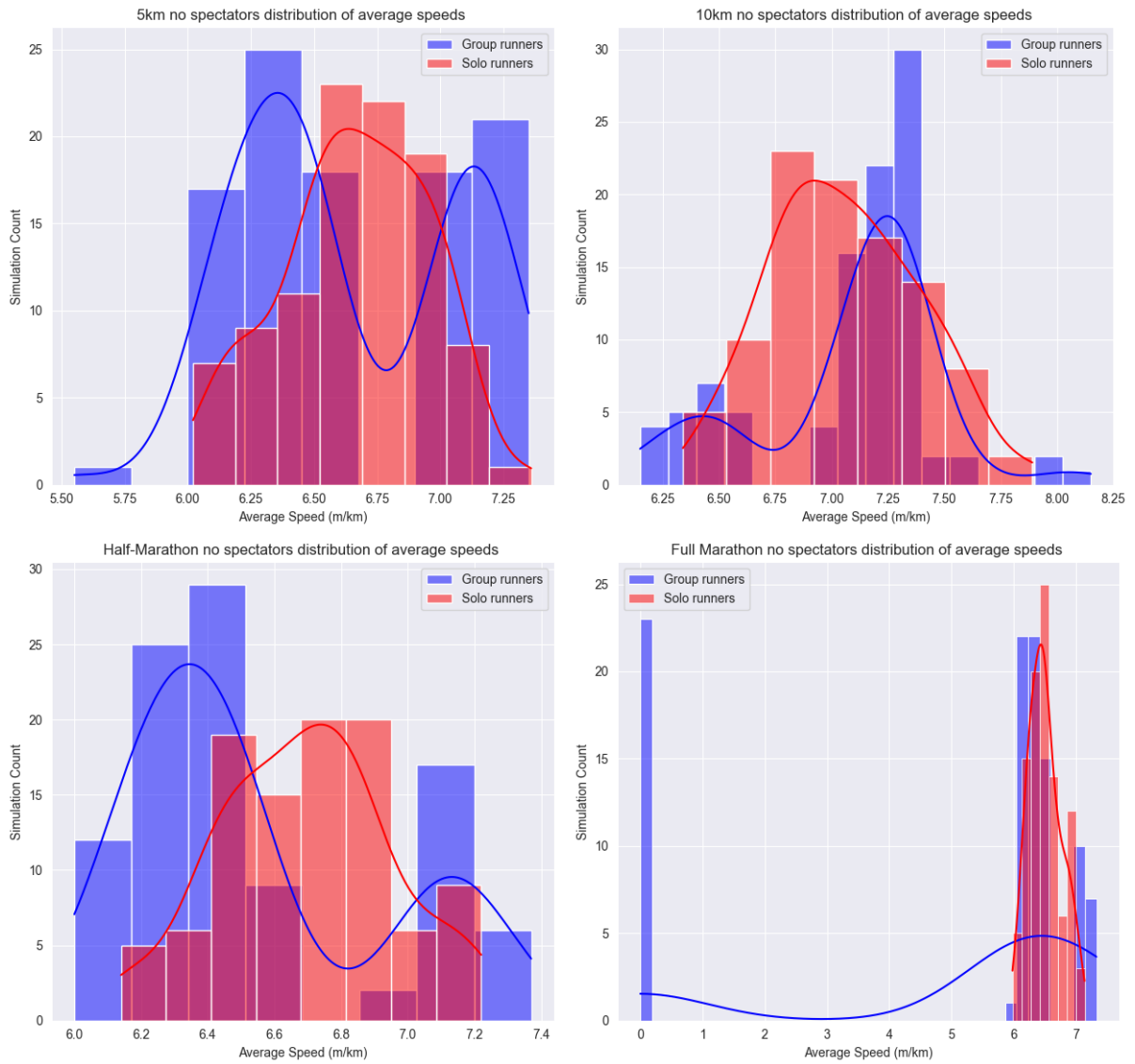
Figure 2: Average Speed Performance

5.1.2 Average Finish Time Performance
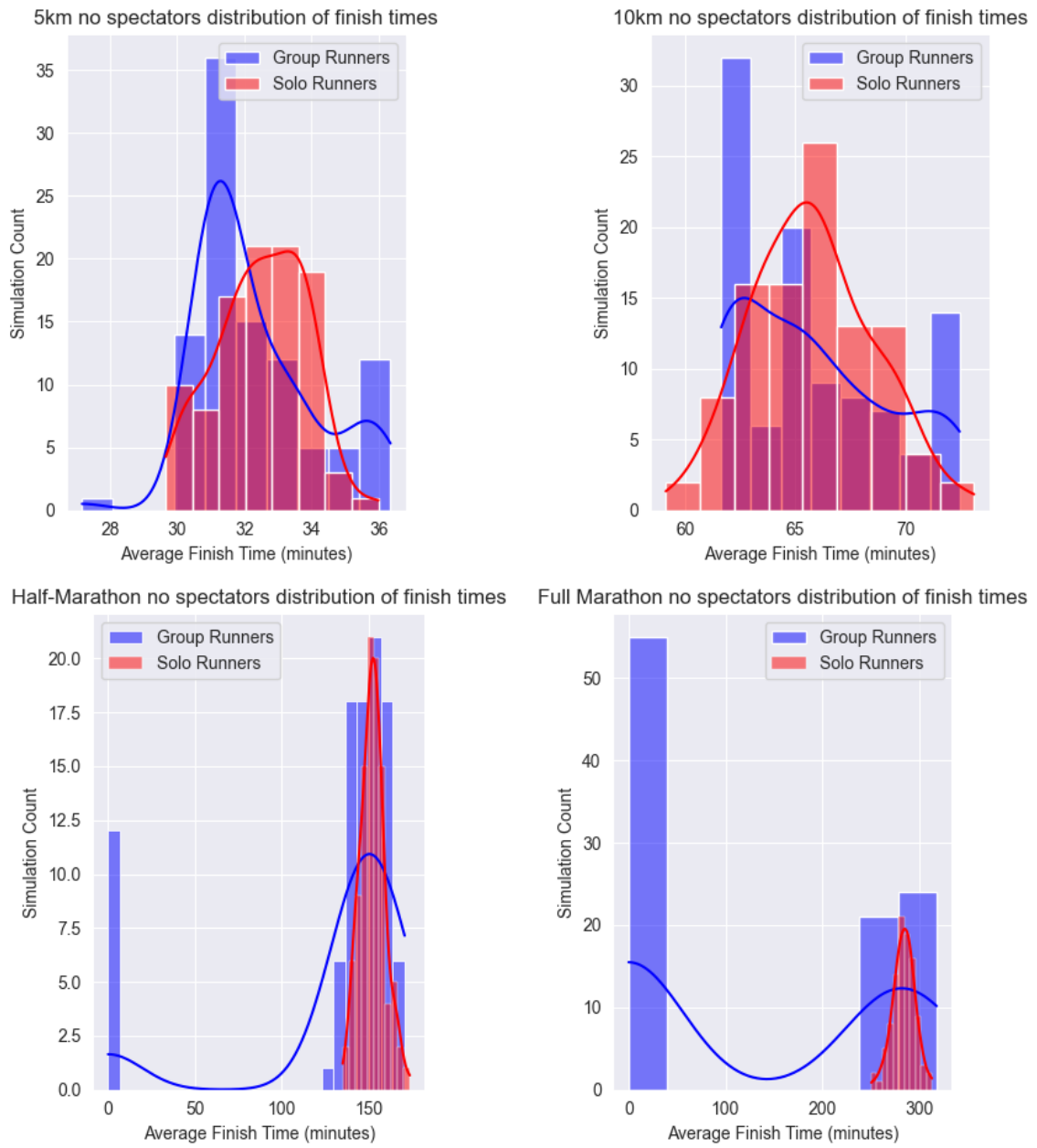
Figure 3: Average Finish Time Performance

5.2   Experiment 2: Dry weather group runners vs solo runners with spectators

Race Event	Test	Statistics	P-Value
5km	Average Speed	-0.119998	0.904626
	Average Finish Time	-0.325621	0.745112
	Socially Susceptible Average Speed	-1.091874	0.276690
	Socially Susceptible Average Finish Time	-1.320493	0.188755
10km	Average Speed	-0.371887	0.710460
	Average Finish Time	-0.766384	0.444568
	Socially Susceptible Average Speed	-0.679867	0.497640
	Socially Susceptible Average Finish Time	-1.137946	0.257075
21km	Average Speed	-4.104612	7.699519e-05
	Average Finish Time	-4.190767	5.913214e-05
	Socially Susceptible Average Speed	-5.460455	2.757469e-07
	Socially Susceptible Average Finish Time	-5.741270	9.623728e-08
42.2km	Average Speed	-7.577456	1.761475e-11
	Average Finish Time	-7.677357	1.106722e-11
	Socially Susceptible Average Speed	-10.298897	1.830295e-17
	Socially Susceptible Average Finish Time	-10.439700	9.848404e-18

Table 3: Statistical Tests Results for Different Race Events

Race Event	Group Sustainability %
5km	100%
10km	89%
21.1km	64%
42.2km	11%

Table 4: Group Sustainability at across 100 simulations
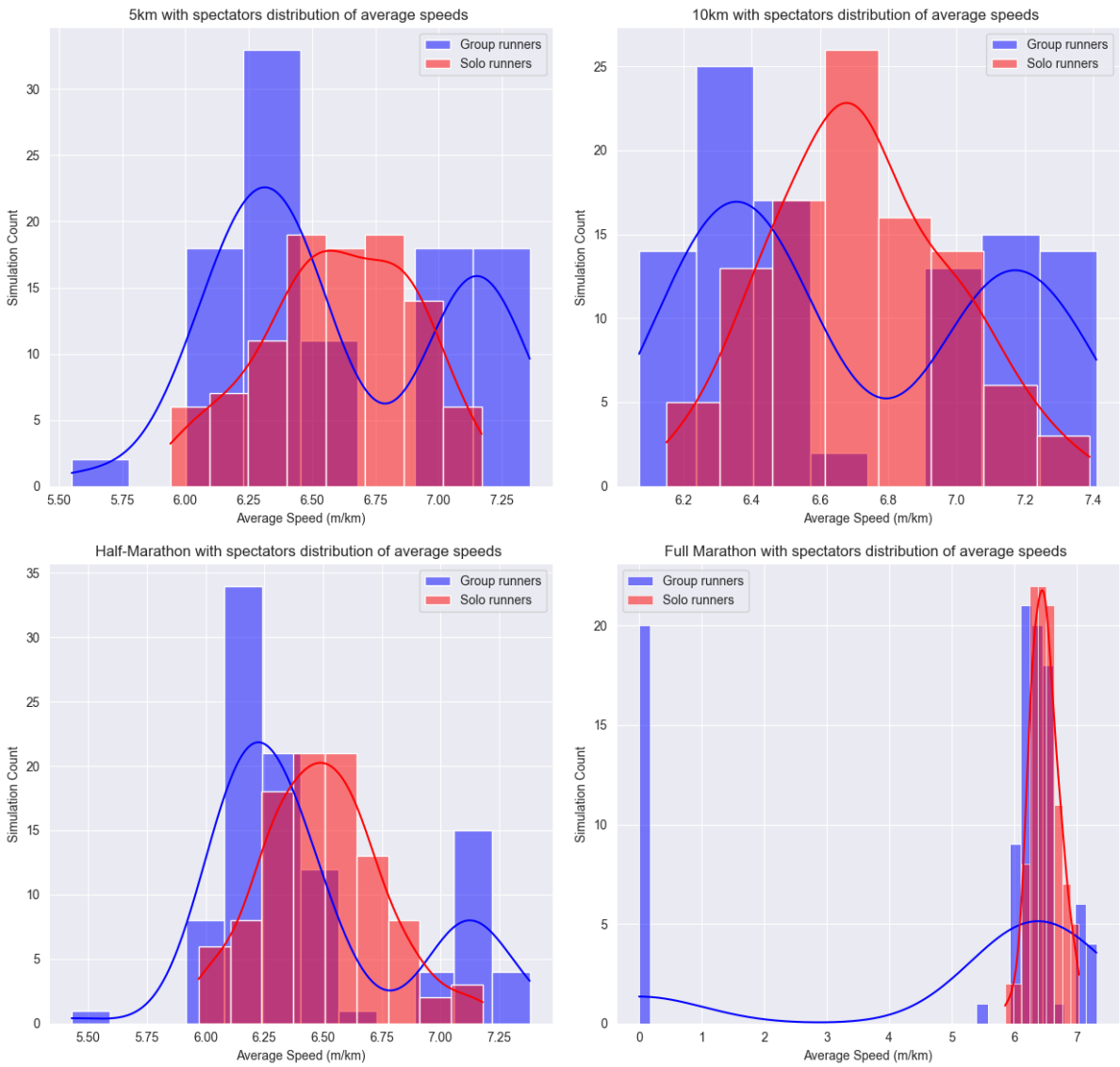
5.2.1   Average Speed Performance

Figure 4: Average Speed Performance
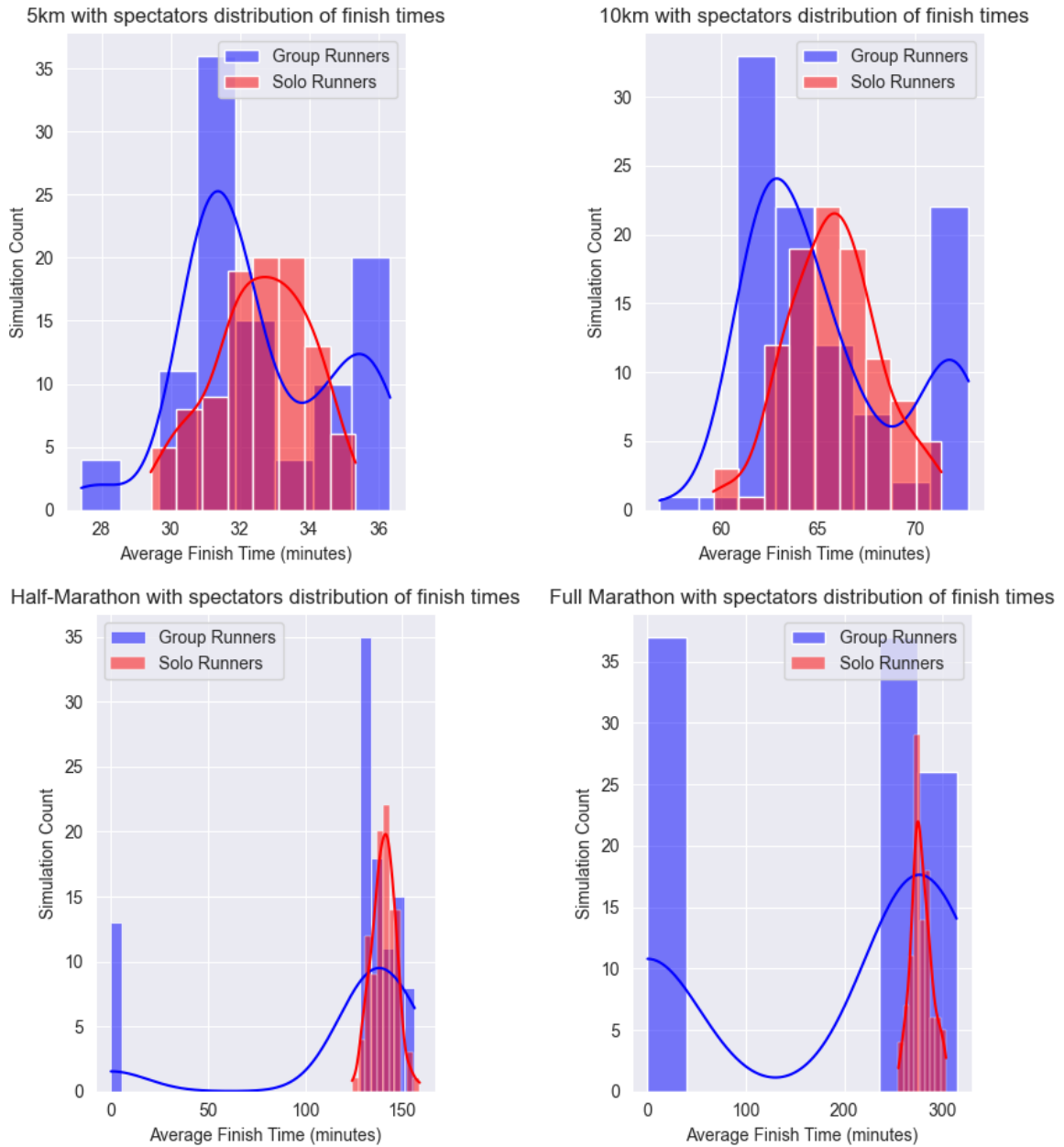
5.2.2   Average Finish Time Performance

Figure 5: Average Finish Time Performance

5.3   Experiment 3: Wet weather group runners vs solo runners and no spectators

Race Event	Test	Statistics	P-Value
5km	Average Speed	-1.459261	0.146080
	Average Finish Time	-0.352413	0.724927
	Socially Susceptible Average Speed	-0.756725	0.450359
	Socially Susceptible Average Finish Time	-0.682120	0.496217
10km	Average Speed	-5.349375	2.943164e-07
	Average Finish Time	-3.268823	1.274533e-03
	Socially Susceptible Average Speed	-2.998851	3.115206e-03
	Socially Susceptible Average Finish Time	-2.849491	5.134741e-03
21km	Average Speed	-2.438667	0.016323
	Average Finish Time	-1.940325	0.055003
	Socially Susceptible Average Speed	-4.518692	0.000017
	Socially Susceptible Average Finish Time	-4.523707	0.000016
42.2km	Average Speed	-3.278722	1.432368e-03
	Average Finish Time	-13.428723	4.417368e-25
	Socially Susceptible Average Speed	-2.952022	3.934219e-03
	Socially Susceptible Average Finish Time	-15.452178	1.131422e-29

Table 5: Statistical Tests Results for Different Race Events

Race Event	Group Sustainability %
5km	99%
10km	87%
21.1km	46%
42.2km	10%

Table 6: Group Sustainability at across 100 simulations

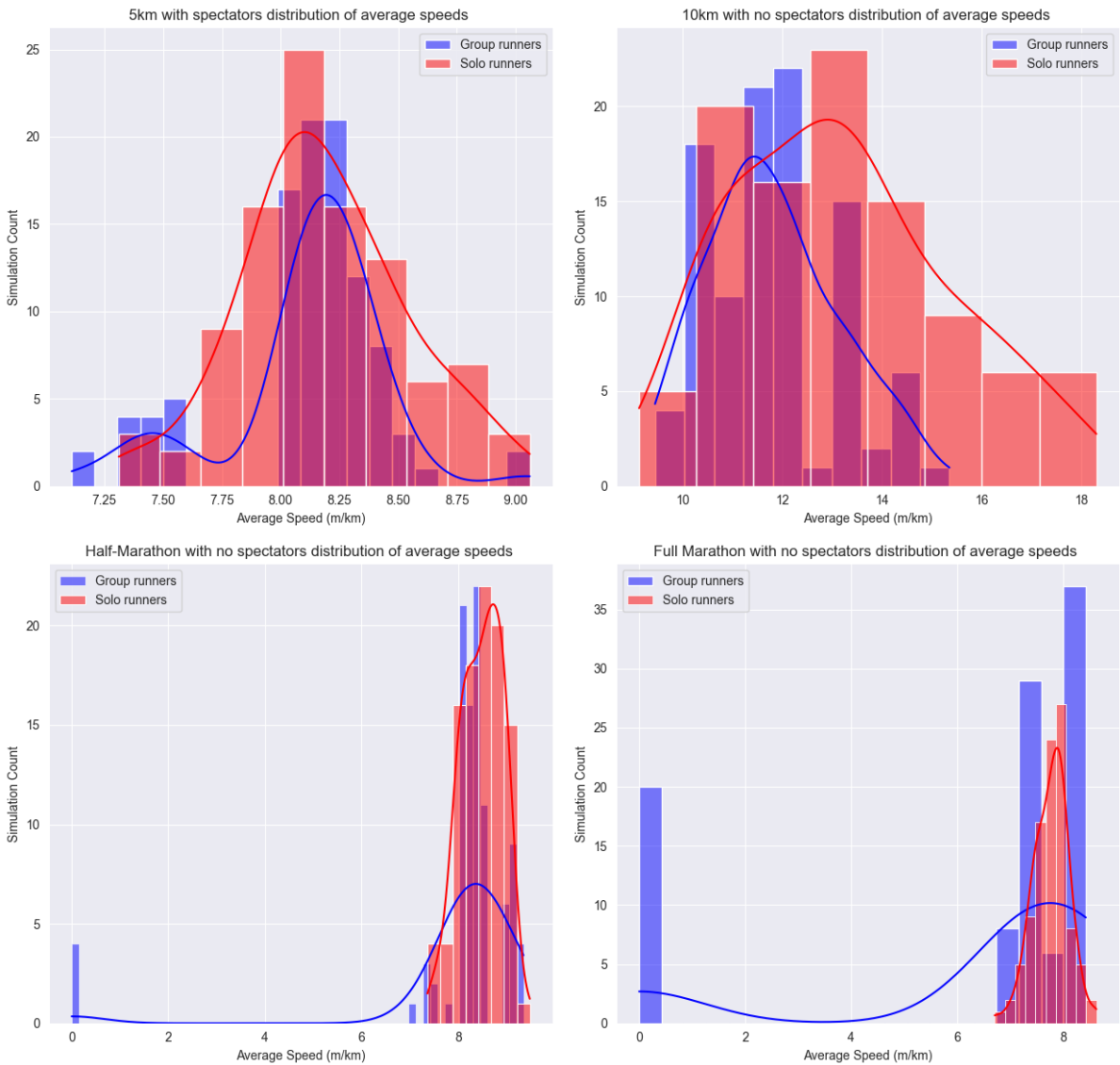### 5.3.1   Average Speed Performance

Figure 6: Average Speed Performance
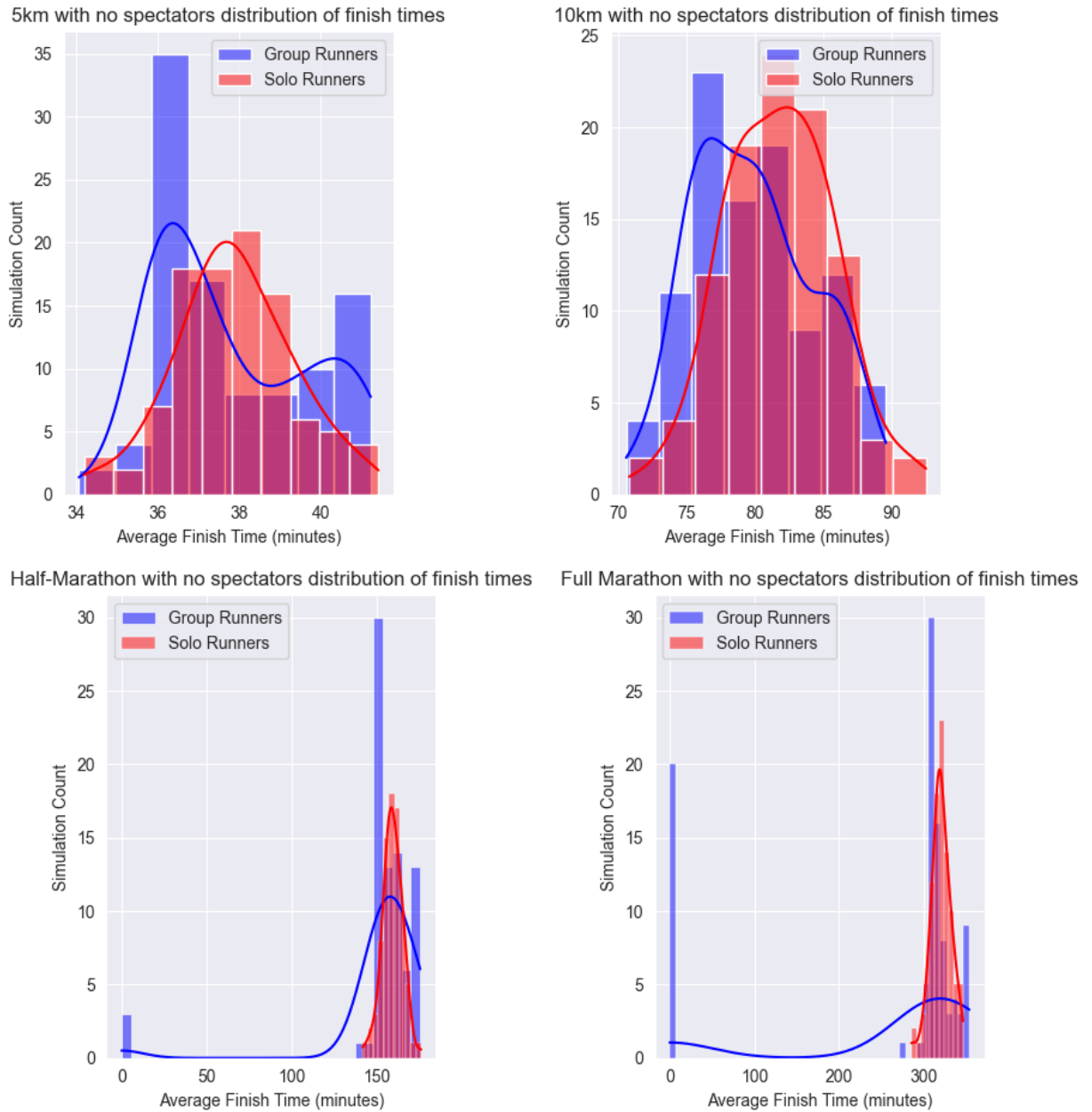
5.3.2   Average Finish Time Performance

Figure 7: Average Finish Times
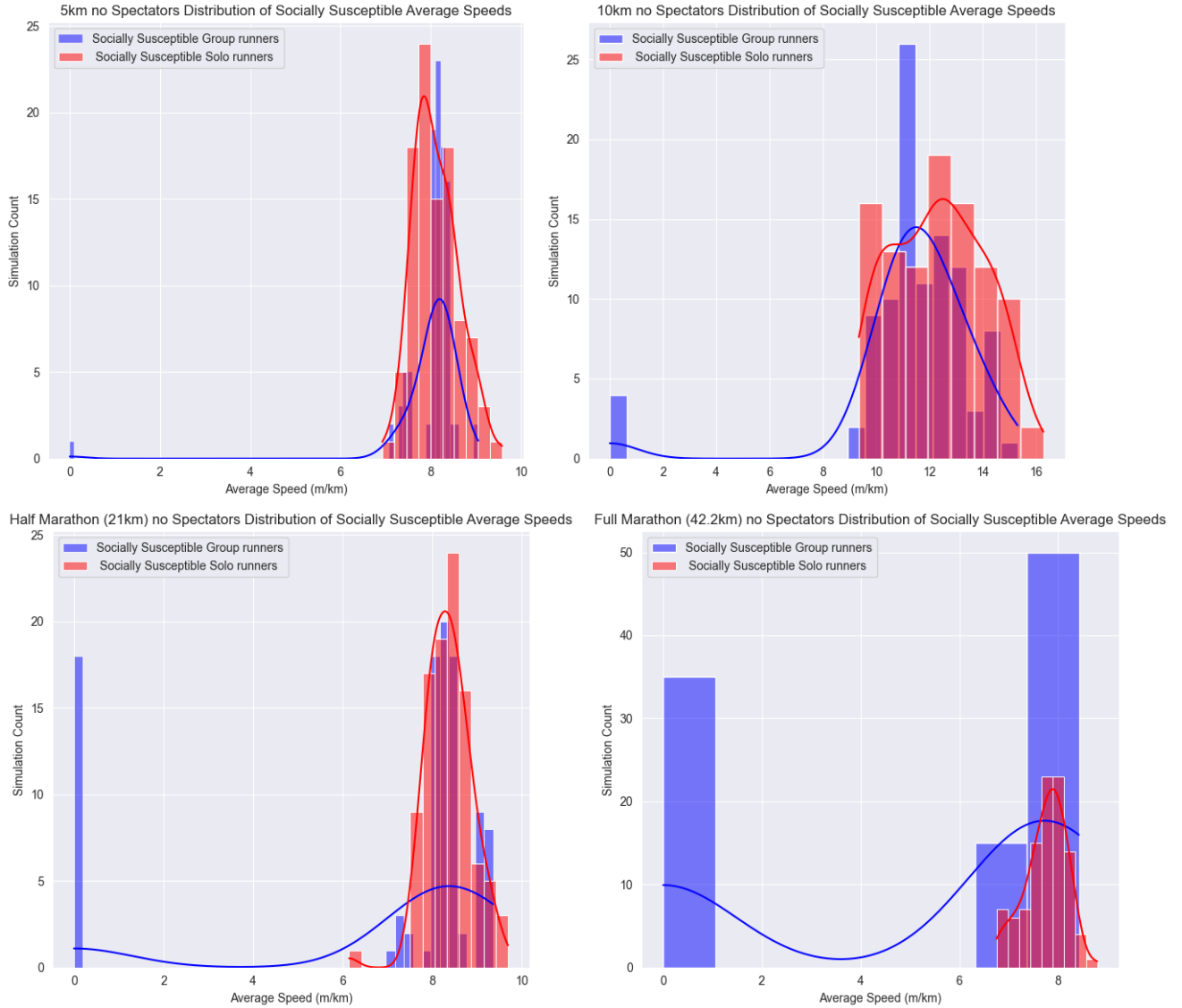
5.4   Socially Susceptible Performance

Figure 8: Average Speed Times

5.5   Experiment 4: Wet weather group runners vs solo runners with spectators

Race Event	Test	Statistics	P-Value
5km	Average Speed	-0.237941	0.812181
	Average Finish Time	-0.740570	0.459861
	Socially Susceptible Average Speed	-0.333591	0.739220
	Socially Susceptible Average Finish Time	-1.363786	0.174966
10km	Average Speed	-2.770182	0.006158
	Average Finish Time	-1.842509	0.066945
	Socially Susceptible Average Speed	1.495460	0.137206
	Socially Susceptible Average Finish Time	-1.681000	0.095329
21km	Average Speed	-3.238089	0.001614
	Average Finish Time	-3.354746	0.001112
	Socially Susceptible Average Speed	-3.294566	0.001345
	Socially Susceptible Average Finish Time	-3.985698	0.000125
42.2km	Average Speed	-10.171499	4.168103e-17
	Average Finish Time	-10.144481	4.876950e-17
	Socially Susceptible Average Speed	-12.938619	3.662749e-23
	Socially Susceptible Average Finish Time	-13.138898	1.448911e-23

Table 7: Statistical Tests Results for Different Race Events

Race Event	Group Sustainability %
5km	99%
10km	85%
21.1km	42%
42.2km	3%

Table 8: Group Sustainability at across 100 simulations

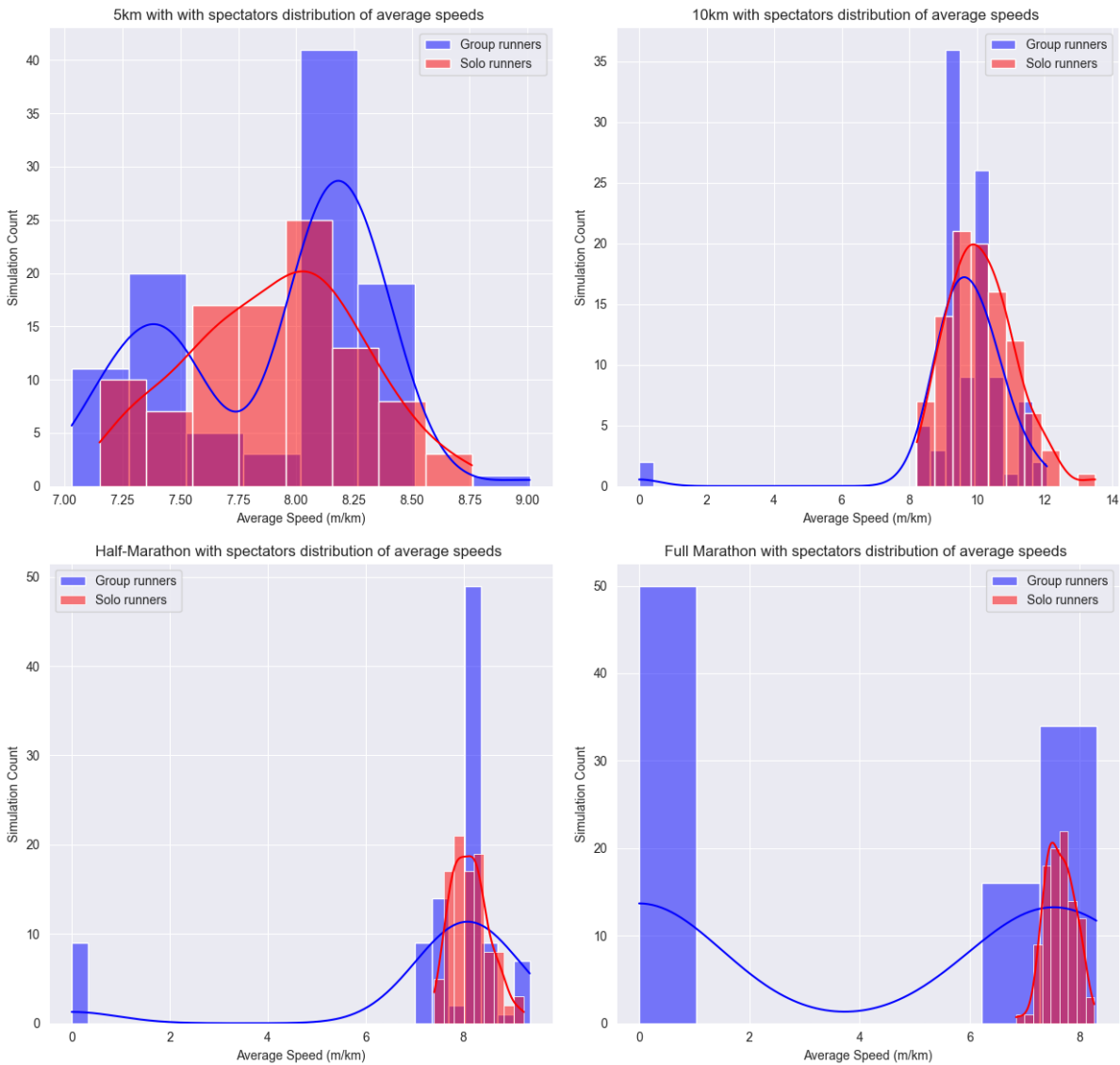### 5.5.1   Average Speed Performance

Figure 9: Average Speed Performance

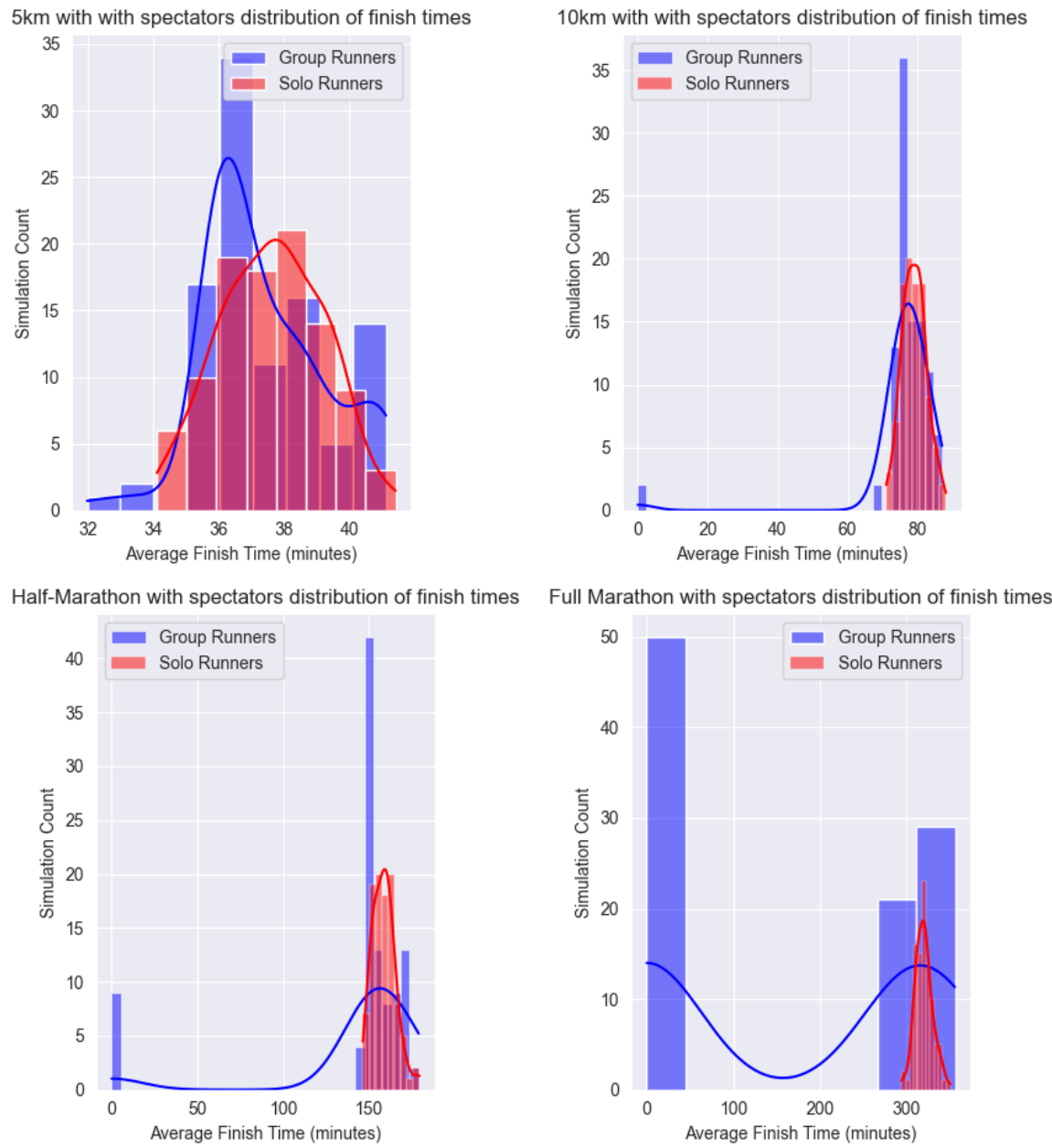### 5.5.2   Average Finish Time Performance

Figure 10: Average Finish Time Performance
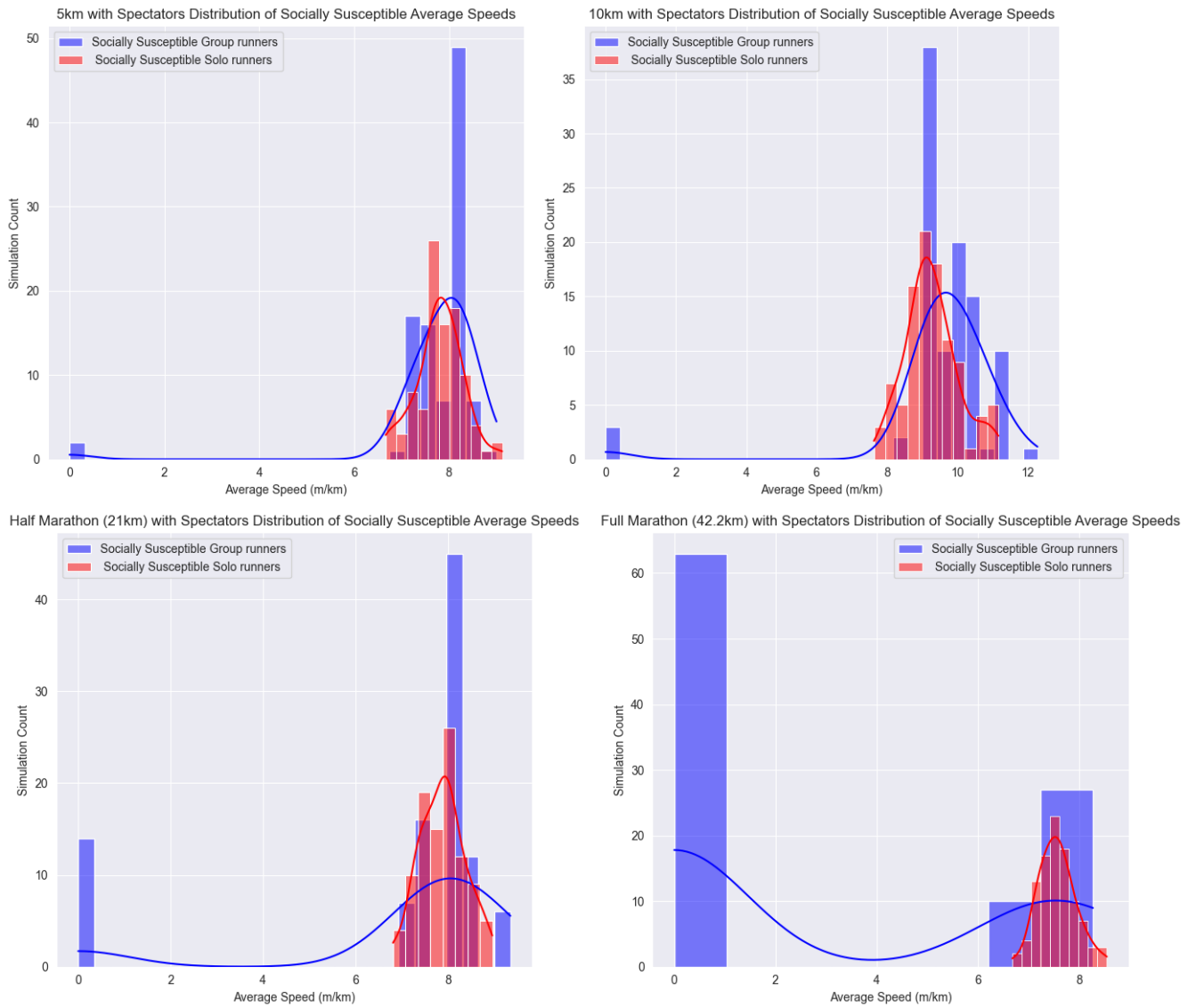
5.5.3   Socially Susceptible Average Speed Performance

Figure 11: Average Finish Time Performance