Analyzing Long-Term Improvement in Adolescent Cross Country Performance

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Abstract:

Running is a rich area to study decision making. When people run, they make decisions about their speed and pace, which determine their overall race performance. Adolescents with minimal experience running, particularly boys, have been studied to be emotionally aggressive when running, sometimes tending to overconfidence, which can lead to a drop in race speed and a loss in time overall. Statistical analysis and qualitative studies of the course itself can be used to identify how these adolescents improve when running long distances.

Male high school runners from Nassau County had their deidentified race times at two courses, Bethpage and Sunken Meadow State Parks, over four years recorded. The data was graphed and analyzed for variance and accuracy through an ANOVA test and Monte Carlo simulation. Runners had much higher variance (f-statistic) on the Sunken Meadow course, though all data was statistically significant with very low p-values. This may be due to obstacles on the course which challenge inexperienced runners to make difficult decisions on pacing and time management, which can trigger feelings of stress and anger.

Introduction:

Sports are ripe for experimentation. They offer psychologists controlled conditions, a set of rules for participants to abide by, and set goals for success. Within sports, there are defined performance metrics, such as race times for running or points scored in basketball. These have a high degree of observability compared to other study methods (Balafoutas et. al 2019). Scientists can study certain mental processes within the context of sports, such as decision-making. Decision-making, in sports, is the sum of the actions that an athlete does during an activity, such as pacing changes during a long distance race in a cross country meet.

Predicting future outcomes, and subsequently over and underestimating success is a valuable skill in sports. In running, estimation of success is shown in pacing, where a long-distance runner will run at a certain speed while gauging their energy level. Overconfidence can be seen with the characteristic sharp increase in pace followed by sharp decrease, displaying that the runner overestimated their ability to increase speed and was forced to slow down. Therefore, slowdown during a race can be used to determine overconfidence levels (Krawczyk and Wilamowski 2018). Longer race distances tend to have higher slowdowns, i.e. more overconfidence. If studied by gender, males have a higher tendency to overestimate their performances, at least in marathons, though other distances have been studied to similar effect. Age

also plays a part, with young male runners having the highest slowdown out of any age group, especially in the marathon (Figure 1).

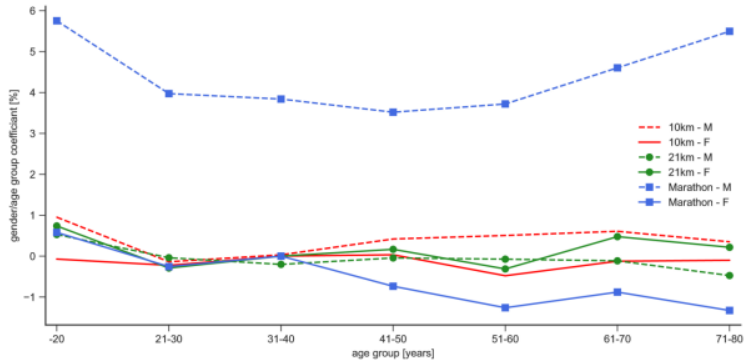

Figure 1:
Race slowdown (RSD) based on age and gender
(Krawczyk and Wilamowski 2018)

Inexperience may be another concern for younger runners slowing down, as they are less likely to know strategy than their older counterparts. Younger runners tend to have high levels of variability in competition, especially when combined with a grueling schedule of three or more competitive races in a month (Hopkins and Hewson 2000). Less time spent running can, of course, spend less time developing the runner's physical abilities, including their oxygen intake and anaerobic power output, both of which are crucial factors in determining running performance (Bulbulian et al. 1986).

Overconfidence may also be due to a heightened emotional state among young runners before they compete. The competitive aspects of running can cause both positive feelings (consonance) and negative feelings (dissonance), both of which reflect as stress. Competitive sports demand certain emotional constructs, such as a fear of the opponent, anger at the performance of others, and a competitive spirit (Lapa et. al 2013). Therefore, the ideal distance runner will have the emotional intelligence and stress tolerance to handle these concerns, although the average teenage runner may have a hard time reaching this ideal in actuality. Many young, competitive runners still have hostile emotional profiles during competition, especially for males (Vasilica et. al 2013).

Statistical analyses are a major part of many sports research projects as well, and a major tool is the ANOVA simulation. ANOVA, or at least the standard one-way ANOVA test, is an analysis of variance that tests the variance between samples against the variance within samples (Chandrakantha 2014). This will output an f-statistic and p-value. The F-statistic shows the variance ratio that is compared to the f-critical values derived from the degrees of freedom, while the p-value shows the statistical significance of the result (Miller 2010). A Monte Carlo simulation is another tool that allows for analysis of the range of possible values when there are unknown factors affecting the data by simulating the data collected many times to create a spread of possible values.

Finally, while statistics may be a powerful tool to determine the mathematical significance of results, sports, which rely heavily on human social and cultural patterns, can also benefit from a qualitative understanding of group and individual psychosocial dynamics. Qualities like team resilience, the capacity for negative stress before it affects performance is almost impossible to quantitatively define, but it can be studied through understanding of the sport at hand and the unique culture and environment of the players, such as a team's taste for humor and experience as a group beyond simple years spent playing together. These factors cannot simply be studied quantitatively, due to the difficulty in creating operational definitions for these concepts, but their effect can be observed through social observations and analysis (Morgan 2019).

Methodology:

First, running data was obtained. The data sources were publicly available repositories of high school cross country data for teams in Nassau and Suffolk Counties. The three sources used were the webpages Just in Time Racing, Section VIII Nassau County Athletics, and NY MileSplit. These sites were recommended by a cross country coach and are updated almost daily with accurate information. Cross country teams on Long Island run 2.4 km, 4 km, or 5 km races on two courses: Bethpage State Park and Sunken Meadow State Park. For each park, the top 250 male runners in 2016 were selected and cross-referenced for accuracy, with the data already de-identified as well. Only males were selected to keep the focus of the project narrowed to improvement within a population (male runners), not the general group of runners. This group of runners had their personal record times for each year recorded on each course as well, until each runner had four times, each corresponding to their four season bests.

To test the hypotheses, the average improvement of a runner had to be determined. For each runner, the times of each subsequent year were subtracted so the change per year could be determined. The difference between their improvement on Bethpage and Sunken Meadow respectively was calculated.

Each grade of high school boys (freshmen, sophomores, juniors, and seniors) had their improvement charted. Each runner was graphed, so the graph would show all 250 lines of improvement over high school, which could be averaged out to find the mean improvement at each point.

Statistics simulations were then conducted using the data. First, ANOVA simulations were conducted for both the Bethpage group and the Sunken Meadow group. The three populations for the test were the three improvements in high school cross country: freshman to sophomore year, sophomore to junior year, and junior to senior year. A standard weighted-means analysis was conducted since all three variables were linked, as each population was the same runner. The ANOVA simulations outputted an

f-statistic on the variance of the data and a p-value about the significance of the variance. Second, a Monte Carlo simulation was conducted using Excel. The scenario given, 250 runners, was replaced with random values within the bounds of the original data set. This was randomized multiple times in a what-if data table which outputted values like the mean, average, and number of times a value was produced outside two standard deviations from the mean.

Results:

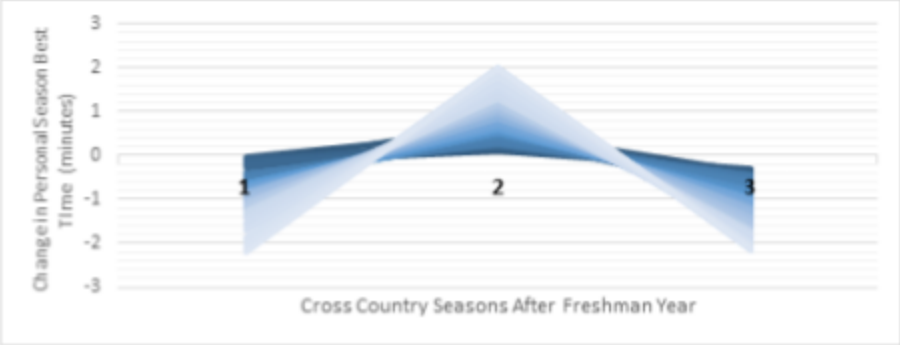

Figure 2: Improvement over Years Ran at Sunken Meadow State Park

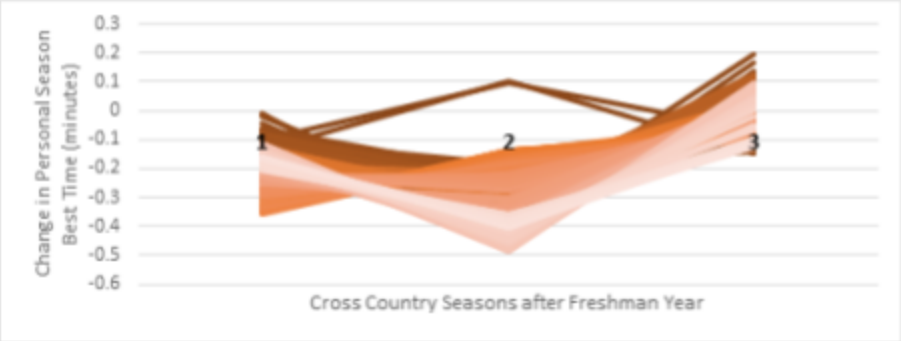

Figure 3: Improvement over Years Ran at Bethpage State Park

The trends for both courses are different. The 250 runners at Sunken Meadow State Park clearly have worse personal bests going into their junior years, then are far faster in their senior years. However, the same runners have the opposite at Bethpage State Park, with a decrease in season best time going into sophomore year that continues even into junior year, where many run their fastest races. However, senior year races on average tend to be the slowest times.

Sunken Meadow State Park has a greater spread of improvement and lack thereof. The range for Sunken Meadow is 4.21 while the range for Bethpage is 0.69. Even when subtracting the averages for each grade level, Sunken Meadow has a range of 1.92 between the averages and Bethpage has a range of 0.298 between averages, so the range is not merely affected by outliers. The standard deviation for

Bethpage was far lower than Sunken Meadow's, with Bethpage having a standard deviation of 0.147 and Sunken Meadow's being 0.971, more than six times greater than Bethpage.

The statistics show a high degree of variability and significance. On the ANOVA tests, both Bethpage and Sunken Meadow had high f-statistic values and low p-values. Sunken Meadow had an extremely high f-statistic of 1212.1, far above the required f-critical value of around 63 to establish meaningful variance. Bethpage's f-statistic was not as high as Sunken Meadow but was still above the f-critical value at 856.03. The high values are likely due to the high number of degrees of freedom resulting from the large data set. Both sets' p-values were extremely low and were less than 0.0001, establishing statistical significance for the results.

The Monte Carlo simulation also supported the veracity of the data. After running many randomizations of the data within the parameters of the data, the result for the range of Bethpage State Park was 0.68 with the overall average being -0.148. The actual range and average from the data set was 0.69 and -0.169 respectively. The simulated data from Sunken Meadow was not noticeably distinct from the actual data as well.

Discussion:

Sunken Meadow obviously had more of a spread than Bethpage State Park. This may seem unexplainable until the courses themselves are considered. The dominant opinion among Long Island cross country coaches and runners is that Sunken Meadow is a far more difficult course. While Bethpage is mostly flat and built on polo grounds, Sunken Meadow features two large hills, Snake Hill and Cardiac Hill, which appear at the 1.25 mi and 2 mi mark respectively. Both hills are sharp inclines of more than 100m, which are reportedly the "abuse" of the course.

Overconfidence studies indicate that the presence of these hills may lead to the variation. Young, male runners, who are already prone to volatile dispositions during running competitions may overestimate the difficulty of the obstacles in front of them (hills) and suffer as a result (Krawczyk and Wilamowski 2018). As experience can lead to better performance in long distance running, students may have their best times senior year after long experience running the course. This experience is mirrored by a lack of experience when starting to run Sunken Meadow, which could cause fewer hostile emotions to be built (Lapa et al. 2012).

Bethpage State Park, on the other hand, has fewer jumps or falls in times. The range is less than 30 seconds of a 5K, a race that takes top runners about 17 minutes to complete. This lack of variability

may be due to the flat, predictable terrain causing less scope for pace overestimation and excess energy expenditure, therefore making results more constant.

A limitation of this study is the difficulty in establishing valid causation. While variability in a race can be analyzed, the actual cause for each meet time and each runner's individual condition cannot be assessed. It is possible that an unfortunate series of events due to weather or scheduling conflicts led to a poor performance across Long Island, skewing the results. Also, Nassau County and Suffolk County runners were not separated, so there could have been certain runners with more experience on one course over the other, though the results showed that most runners followed the dominant trends.

Conclusion:

Sports, by their nature, reflect the human spirit of defiance and resilience. For a runner, each step they take is a decision to continue moving forward. However, as the results show, the sum of these decisions, i.e. the race time can be influenced by psychological factors resulting from the course. The obstacles at Sunken Meadow, namely the looming hills, may cause runners to misjudge their success during a race, leading to large swings in performance. This is especially true when compared to its counterpart Bethpage State Park, which has a smaller spread in performance, as shown by the f-statistics from the ANOVA test. While this study was statistically significant, much work is required to discover exactly what mental states are required to minimize the inconsistency in running, especially at an adolescent level where mental processes and puberty can lead to sometimes irrational behavior.

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