

Optimizing Marathon Performance

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Introduction: This research project develops a predictive model for marathon performance, integrating economic and training location factors. It identifies cities that offer optimal conditions for performance improvement and cost efficiency, emphasizing early and extended training periods.

Data Testing (Various Cases)

Small Dataset (Original Values) from Women's Marathon Data (2015-2019) | 25-29 Age Category (Each Data Point a unique city)

1) (Mode = 8)

Location	Starting Age	Final Age	Starting Grade	Final Grade	Cost of Living
Acton, MA	27	27	9	9	53860
Agua Dulce	26	26	6	6	53171
Alameda, CA	28	28	8	8	53171
San Francisco	26	27	8	5	53171
Wilmington	28	28	7	7	44389
Windham, NH	26	26	9	9	45575
Yonkers, NY	29	29	5	5	49623

The starting grade considered is the mode of Starting Grades: 8
Cities with the maximum Predicted Grade Change:
Wilmington, DE: Predicted Change = -12.0, Final Grade = -4.0, Cost of Living = 44389
Windham, NH: Predicted Change = -12.0, Final Grade = -4.0, Cost of Living = 45575
Yonkers, NY: Predicted Change = -12.0, Final Grade = -4.0, Cost of Living = 49623
Agua Dulce, CA: Predicted Change = -12.0, Final Grade = -4.0, Cost of Living = 53171
Alameda, CA: Predicted Change = -12.0, Final Grade = -4.0, Cost of Living = 53171
San Francisco, CA: Predicted Change = -12.0, Final Grade = -4.0, Cost of Living = 53171
Acton, MA: Predicted Change = -12.0, Final Grade = -4.0, Cost of Living = 53860

The starting grade considered is the mode of Starting Grades: 5
Cities with the maximum Predicted Grade Change:
Wilmington, DE: Predicted Change = -12.0, Final Grade = -7.0, Cost of Living = 44389
Windham, NH: Predicted Change = -12.0, Final Grade = -7.0, Cost of Living = 45575
Yonkers, NY: Predicted Change = -12.0, Final Grade = -7.0, Cost of Living = 49623
Agua Dulce, CA: Predicted Change = -12.0, Final Grade = -7.0, Cost of Living = 53171
Alameda, CA: Predicted Change = -12.0, Final Grade = -7.0, Cost of Living = 53171
San Francisco, CA: Predicted Change = -12.0, Final Grade = -7.0, Cost of Living = 53171
Acton, MA: Predicted Change = -12.0, Final Grade = -7.0, Cost of Living = 53860

The starting grade considered is the mode of Starting Grades: 2
Cities with the maximum Predicted Grade Change:
Wilmington, DE: Predicted Change = -12.0, Final Grade = -10.0, Cost of Living = 44389
Windham, NH: Predicted Change = -12.0, Final Grade = -10.0, Cost of Living = 45575
Yonkers, NY: Predicted Change = -12.0, Final Grade = -10.0, Cost of Living = 49623
Agua Dulce, CA: Predicted Change = -12.0, Final Grade = -10.0, Cost of Living = 53171
Alameda, CA: Predicted Change = -12.0, Final Grade = -10.0, Cost of Living = 53171
San Francisco, CA: Predicted Change = -12.0, Final Grade = -10.0, Cost of Living = 53171
Acton, MA: Predicted Change = -12.0, Final Grade = -10.0, Cost of Living = 53860

1. Starting Grade Sum = 52, Final Grade Sum = 49.

1A. (Mode = 8)

Different from Case 1 - San Francisco's age =>(25, 25)

Location	Starting Age	Final Age	Starting Gr	Final Grade	Cost of Living
Acton, MA	27	27	9	9	53860
Agua Dulce	26	26	6	6	53171
Alameda, CA	28	28	8	8	53171
San Francisco, CA	25	25	8	5	53171
Wilmington, DE	28	28	7	7	44389
Windham, NH	26	26	9	9	45575
Yonkers, NY	29	29	5	5	49623

The starting grade considered is the mode of Starting Grades: 8
Cities with the maximum Predicted Grade Change:
Yonkers, NY: Predicted Change = -0.704, Final Grade = 7.296, Cost of Living = 49623

From Case 1,

Location	Starting Age	Final Age	Starting Gr	Final Grade	Cost of Living
Acton, MA	27	27	9	9	53860
Agua Dulce	26	26	6	6	53171
Alameda, CA	28	28	8	8	53171
San Francisco, CA	26	27	8	5	53171
Wilmington, DE	28	28	7	7	44389
Windham, NH	26	26	9	9	45575
Yonkers, NY	29	29	5	5	49623

The starting grade considered is the mode of Starting Grades: 8
Cities with the maximum Predicted Grade Change:
Wilmington, DE: Predicted Change = -12.0, Final Grade = -4.0, Cost of Living = 44389
Windham, NH: Predicted Change = -12.0, Final Grade = -4.0, Cost of Living = 45575
Yonkers, NY: Predicted Change = -12.0, Final Grade = -4.0, Cost of Living = 49623
Agua Dulce, CA: Predicted Change = -12.0, Final Grade = -4.0, Cost of Living = 53171
Alameda, CA: Predicted Change = -12.0, Final Grade = -4.0, Cost of Living = 53171
San Francisco, CA: Predicted Change = -12.0, Final Grade = -4.0, Cost of Living = 53171
Acton, MA: Predicted Change = -12.0, Final Grade = -4.0, Cost of Living = 53860

One more condition, **1B**, wherein we keep condition 1A the same, but changes times spent in Action from 27 to 27 -> 27 to 28,

Location	Starting Age	Final Age	Starting Gr	Final Grade	Cost of Living
Acton, MA	27	28	9	9	53860
Agua Dulce	26	26	6	6	53171
Alameda, CA	28	28	8	8	53171
San Francisco, CA	25	25	8	5	53171
Wilmington, DE	28	28	7	7	44389
Windham, NH	26	26	9	9	45575
Yonkers, NY	29	29	5	5	49623

The starting grade considered is the mode of Starting Grades: 8
Cities with the maximum Predicted Grade Change:
Yonkers, NY: Predicted Change = -2.105, Final Grade = 5.895, Cost of Living = 49623

1C, wherein Case 1 is maintained, but the final grade for San Francisco changed to 9,

Location	Starting Age	Final Age	Starting Grade	Final Grade	Cost of Living
Acton, MA	27	27	9	9	53860
Agua Dulce	26	26	6	6	53171
Alameda, CA	28	28	8	8	53171
San Francisco, CA	26	27	8	9	53171
Wilmington, DE	28	28	7	7	44389
Windham, NH	26	26	9	9	45575
Yonkers, NY	29	29	5	5	49623

The starting grade considered is the mode of Starting Grades: 8
 Cities with the maximum Predicted Grade Change:
 Wilmington, DE: Predicted Change = 4.0, Final Grade = 12.0, Cost of Living = 44389
 Windham, NH: Predicted Change = 4.0, Final Grade = 12.0, Cost of Living = 45575
 Yonkers, NY: Predicted Change = 4.0, Final Grade = 12.0, Cost of Living = 49623
 Agua Dulce, CA: Predicted Change = 4.0, Final Grade = 12.0, Cost of Living = 53171
 Alameda, CA: Predicted Change = 4.0, Final Grade = 12.0, Cost of Living = 53171
 San Francisco, CA: Predicted Change = 4.0, Final Grade = 12.0, Cost of Living = 53171
 Acton, MA: Predicted Change = 4.0, Final Grade = 12.0, Cost of Living = 53860

2) (Mode = 5) Except for Acton, everywhere, grades gets worse
 Slightly modified from Case 1 (Grades Changed)

Location	Starting Age	Final Age	Starting Grade	Final Grade	Cost of Living
Acton, MA	27	27	9	6	53860
Agua Dulce	26	26	5	6	53171
Alameda, CA	28	28	7	8	53171
San Francisco, CA	26	27	3	5	53171
Wilmington, DE	28	28	6	7	44389
Windham, NH	26	26	6	9	45575
Yonkers, NY	29	29	5	9	49623

The starting grade considered is the mode of Starting Grades: 5
 Cities with the maximum Predicted Grade Change:
 Acton, MA: Predicted Change = -6.751, Final Grade = -1.751, Cost of Living = 53860

The starting grade considered is the mode of Starting Grades: 8
 Cities with the maximum Predicted Grade Change:
 Acton, MA: Predicted Change = -9.063, Final Grade = -1.063, Cost of Living = 53860

The starting grade considered is the mode of Starting Grades: 2
 Cities with the maximum Predicted Grade Change:
 Acton, MA: Predicted Change = -4.439, Final Grade = -2.439, Cost of Living = 53860

The starting grade considered is the mode of Starting Grades: 3
 Cities with the maximum Predicted Grade Change:
 Acton, MA: Predicted Change = -5.21, Final Grade = -2.21, Cost of Living = 53860

1. Predicted Change(Grade5)-Predicted Change(Grade8) = Predicted Change(Grade2)-Predicted Change(Grade5) = 2.312
2. Change in Predicted Change Per Positive Grade shift as a Starting Rank = 0.77
3. The magnitude of Predicted Change Decreases with the positive shift in Grade.
4. Starting Grade Sum = 41, Final Grade Sum = 50.

2A. (Mode = 5)

Location	Starting Age	Final Age	Starting Grade	Final Grade	Cost of Living
Acton, MA	27	27	9	6	53860
Agua Dulce	26	26	5	6	53171
Alameda, CA	28	28	7	8	53171
San Francisco	25	25	3	5	53171
Wilmington	28	28	6	7	44389
Windham, VT	26	26	6	9	45575
Yonkers, NY	29	29	5	9	49623

The starting grade considered is the mode of Starting Grades: 5
Cities with the maximum Predicted Grade Change:
Acton, MA: Predicted Change = -0.258, Final Grade = 4.742, Cost of Living = 53860

From Case 2,

Location	Starting Age	Final Age	Starting Grade	Final Grade	Cost of Living
Acton, MA	27	27	9	6	53860
Agua Dulce	26	26	5	6	53171
Alameda, CA	28	28	7	8	53171
San Francisco	26	27	3	5	53171
Wilmington	28	28	6	7	44389
Windham, VT	26	26	6	9	45575
Yonkers, NY	29	29	5	9	49623

The starting grade considered is the mode of Starting Grades: 5
Cities with the maximum Predicted Grade Change:
Acton, MA: Predicted Change = -6.751, Final Grade = -1.751, Cost of Living = 53860

One more condition, **2B**, wherein we increase the time spent in Acton,

Location	Starting Age	Final Age	Starting Grade	Final Grade	Cost of Living
Acton, MA	27	28	9	6	53860
Agua Dulce	26	26	5	6	53171
Alameda, CA	28	28	7	8	53171
San Francisco	25	25	3	5	53171
Wilmington	28	28	6	7	44389
Windham, VT	26	26	6	9	45575
Yonkers, NY	29	29	5	9	49623

The starting grade considered is the mode of Starting Grades: 5
Cities with the maximum Predicted Grade Change:
Acton, MA: Predicted Change = -8.881, Final Grade = -3.881, Cost of Living = 53860

=> From 2 & 2A & 2B,

We can infer that living in a city for a longer duration increases the magnitude of grade change. The increase is much greater in a city with a positive grade improvement.

3) (Mode = 5)

Slightly modified from Case 2 (San Francisco, Starting Age Changed to 25)

Location	Starting Age	Final Age	Starting Grade	Final Grade	Cost of Living
Acton, MA	27	27	9	6	53860
Agua Dulce	26	26	5	6	53171
Alameda, CA	28	28	7	8	53171
San Francisco	25	27	3	5	53171
Wilmington	28	28	6	7	44389
Windham, NH	26	26	6	9	45575
Yonkers, NY	29	29	5	9	49623

The starting grade considered is the mode of Starting Grades: 5
Cities with the maximum Predicted Grade Change:
Acton, MA: Predicted Change = -3.238, Final Grade = 1.762, Cost of Living = 53860

The starting grade considered is the mode of Starting Grades: 8
Cities with the maximum Predicted Grade Change:
Acton, MA: Predicted Change = -5.55, Final Grade = 2.45, Cost of Living = 53860

The starting grade considered is the mode of Starting Grades: 2
Cities with the maximum Predicted Grade Change:
Acton, MA: Predicted Change = -0.926, Final Grade = 1.074, Cost of Living = 53860

The starting grade considered is the mode of Starting Grades: 3
Cities with the maximum Predicted Grade Change:
Acton, MA: Predicted Change = -1.697, Final Grade = 1.303, Cost of Living = 53860

1. Predicted Change(Grade5)-Predicted Change(Grade8) = Predicted Change(Grade2)-Predicted Change(Grade5) = 2.312
2. Change in Predicted Change Per Positive Grade shift as a Starting Rank = 0.77
3. The magnitude of Predicted Change Decreases with the positive shift in Grade.
4. Starting Grade Sum = 41, Final Grade Sum = 50.

- By increasing the year spent in San Francisco, the magnitude of Grade Change decreased by 3.513 for the same starting rank.

3A. (Mode = 5)

Slightly modified case of Case 3 (Rather than changing 26 to 25(starting age) in Case 2, we changed, 27 to 28(final age) for San Francisco).

Location	Starting Age	Final Age	Starting Grade	Final Grade	Cost of Living
Acton, MA	27	27	9	6	53860
Agua Dulce	26	26	5	6	53171
Alameda, CA	28	28	7	8	53171
San Francisco	26	28	3	5	53171
Wilmington	28	28	6	7	44389
Windham, VT	26	26	6	9	45575
Yonkers, NY	29	29	5	9	49623

The starting grade considered is the mode of Starting Grades: 5
 Cities with the maximum Predicted Grade Change:
 Acton, MA: Predicted Change = -3.11, Final Grade = 1.89, Cost of Living = 53860

From Case 3

Location	Starting Age	Final Age	Starting Grade	Final Grade	Cost of Living
Acton, MA	27	27	9	6	53860
Agua Dulce	26	26	5	6	53171
Alameda, CA	28	28	7	8	53171
San Francisco	25	27	3	5	53171
Wilmington	28	28	6	7	44389
Windham, VT	26	26	6	9	45575
Yonkers, NY	29	29	5	9	49623

The starting grade considered is the mode of Starting Grades: 5
 Cities with the maximum Predicted Grade Change:
 Acton, MA: Predicted Change = -3.238, Final Grade = 1.762, Cost of Living = 53860

- An increase in the magnitude of Grade change if we start living in San Francisco early.

4) (Mode = 5)

Slightly changed from Case 3 => Acton's final age changed to 28; San Francisco's starting age changed to 26.

Location	Starting Age	Final Age	Starting Grade	Final Grade	Cost of Living
Acton, MA	27	28	9	6	53860
Agua Dulce	26	26	5	6	53171
Alameda, CA	28	28	7	8	53171
San Francisco	26	27	3	5	53171
Wilmington	28	28	6	7	44389
Windham, VT	26	26	6	9	45575
Yonkers, NY	29	29	5	9	49623

The starting grade considered is the mode of Starting Grades: 5
Cities with the maximum Predicted Grade Change:
Acton, MA: Predicted Change = -4.53, Final Grade = 0.47, Cost of Living = 53860

The starting grade considered is the mode of Starting Grades: 8
Cities with the maximum Predicted Grade Change:
Acton, MA: Predicted Change = -6.089, Final Grade = 1.911, Cost of Living = 53860

The starting grade considered is the mode of Starting Grades: 2
Cities with the maximum Predicted Grade Change:
Acton, MA: Predicted Change = -2.972, Final Grade = -0.972, Cost of Living = 53860

The starting grade considered is the mode of Starting Grades: 3
Cities with the maximum Predicted Grade Change:
Acton, MA: Predicted Change = -3.491, Final Grade = -0.491, Cost of Living = 53860

1. Predicted Change(Grade5)-Predicted Change(Grade8) = Predicted Change(Grade2)-Predicted Change(Grade5) = 1.558
2. Change in Predicted Change Per Positive Grade shift as a Starting Rank = 0.519
3. The magnitude of Predicted Change Decreases with the positive shift in Grade.
4. Starting Grade Sum = 41, Final Grade Sum = 50.
5. By increasing the year spent in Acton, the magnitude of Grade Change decreased by 2.221 for the same starting rank.

4A. (Mode = 5)

Slightly modified case of Case 4 (Rather than spending 27 to 28, we changed it to 26 to 27)

Location	Starting Age	Final Age	Starting Grade	Final Grade	Cost of Living
Acton, MA	26	27	9	6	53860
Agua Dulce	26	26	5	6	53171
Alameda, CA	28	28	7	8	53171
San Francisco	26	27	3	5	53171
Wilmington	28	28	6	7	44389
Windham, VT	26	26	6	9	45575
Yonkers, NY	29	29	5	9	49623

The starting grade considered is the mode of Starting Grades: 5
 Cities with the maximum Predicted Grade Change:
 Acton, MA: Predicted Change = -4.653, Final Grade = 0.347, Cost of Living = 53860

From Case 4

Location	Starting Age	Final Age	Starting Grade	Final Grade	Cost of Living
Acton, MA	27	28	9	6	53860
Agua Dulce	26	26	5	6	53171
Alameda, CA	28	28	7	8	53171
San Francisco	26	27	3	5	53171
Wilmington	28	28	6	7	44389
Windham, VT	26	26	6	9	45575
Yonkers, NY	29	29	5	9	49623

The starting grade considered is the mode of Starting Grades: 5
 Cities with the maximum Predicted Grade Change:
 Acton, MA: Predicted Change = -4.53, Final Grade = 0.47, Cost of Living = 53860

1. An increase in the magnitude of Grade change if we start living in Acton early.

=> From 3A & 4A,

We can infer that living in any city during the early years of the particular category, we can achieve more grade change.

Actual Model (Women's Marathon Data)

The starting grade considered is the mode of Starting Grades: 9
 Cities with the maximum Predicted Grade Change:
 Albuquerque, NM: Predicted Change = -2.339, Final Grade = 6.661, Cost of Living = 34501
 Alpharetta, GA: Predicted Change = -2.339, Final Grade = 6.661, Cost of Living = 38747
 Alexandria, VA: Predicted Change = -2.339, Final Grade = 6.661, Cost of Living = 43067
 Agua Dulce, CA: Predicted Change = -2.339, Final Grade = 6.661, Cost of Living = 53171
 Alameda, CA: Predicted Change = -2.339, Final Grade = 6.661, Cost of Living = 53171
 Altadena, CA: Predicted Change = -2.339, Final Grade = 6.661, Cost of Living = 53171
 Acton, MA: Predicted Change = -2.339, Final Grade = 6.661, Cost of Living = 53860

The starting grade considered is the mode of Starting Grades: 6

Cities with the maximum Predicted Grade Change:

Albuquerque, NM: Predicted Change = -2.297, Final Grade = 3.703, Cost of Living = 34501
Alpharetta, GA: Predicted Change = -2.297, Final Grade = 3.703, Cost of Living = 38747
Alexandria, VA: Predicted Change = -2.297, Final Grade = 3.703, Cost of Living = 43067
Annapolis, MD: Predicted Change = -2.297, Final Grade = 3.703, Cost of Living = 48235
Agua Dulce, CA: Predicted Change = -2.297, Final Grade = 3.703, Cost of Living = 53171
Alameda, CA: Predicted Change = -2.297, Final Grade = 3.703, Cost of Living = 53171
Altadena, CA: Predicted Change = -2.297, Final Grade = 3.703, Cost of Living = 53171
Arroyo Grande, CA: Predicted Change = -2.297, Final Grade = 3.703, Cost of Living = 53171
Acton, MA: Predicted Change = -2.297, Final Grade = 3.703, Cost of Living = 53860

The starting grade considered is the mode of Starting Grades: 3

Cities with the maximum Predicted Grade Change:

Albuquerque, NM: Predicted Change = -2.255, Final Grade = 0.745, Cost of Living = 34501
Alpharetta, GA: Predicted Change = -2.255, Final Grade = 0.745, Cost of Living = 38747
Alexandria, VA: Predicted Change = -2.255, Final Grade = 0.745, Cost of Living = 43067
Annapolis, MD: Predicted Change = -2.255, Final Grade = 0.745, Cost of Living = 48235
Agua Dulce, CA: Predicted Change = -2.255, Final Grade = 0.745, Cost of Living = 53171
Alameda, CA: Predicted Change = -2.255, Final Grade = 0.745, Cost of Living = 53171
Altadena, CA: Predicted Change = -2.255, Final Grade = 0.745, Cost of Living = 53171
Arroyo Grande, CA: Predicted Change = -2.255, Final Grade = 0.745, Cost of Living = 53171
Atherton, CA: Predicted Change = -2.255, Final Grade = 0.745, Cost of Living = 53171
Acton, MA: Predicted Change = -2.255, Final Grade = 0.745, Cost of Living = 53860