The Best Cities in the U.S. for High-Level Running

Abstract

This study investigates the environmental factors that optimize endurance running performance, with a focus on temperature, elevation, and precipitation. By analyzing 30 years of METAR (Meteorological Aerodrome Report) data across 2,223 sites in the contiguous United States, we establish criteria for Ideal Running Days (IRD) defined by temperatures between 50°F and 63.5°F with no precipitation. Our findings indicate that the Pacific Northwest, particularly Northern California and Southern Oregon, provides favorable climatic conditions for running. However, when incorporating elevation data, New Mexico emerges as the premier U.S. location, boasting ideal elevations between 1,500 and 3,000 meters along with a significant number of IRDs.

Introduction

Elite athletic training demands not only intense, targeted physical effort but also precisely optimized and conducive environments. For endurance athletes, specific conditions-such as high elevations and temperate weather-are pivotal in achieving peak performance. This is why runners flock to renowned training hubs like Eldoret, Kenya, and Colorado Springs, Colorado. But do these locations truly provide the best conditions for endurance training, particularly for running? What are the optimal conditions that enhance running performance, and which locations offer the most advantageous environments?

A review of the literature suggests that two of the most important factors are temperature and elevation. Temperature is well-documented as a crucial element in exercise performance, especially for sustained, high-intensity activity (Grahn et al., 2012). During physical exertion, muscles generate considerable heat. However, if this heat accumulates excessively, muscle performance can decline sharply. To counteract this, the body employs several thermoregulatory mechanisms, primarily through increased blood flow and sweating, to dissipate heat effectively. Blood circulation functions much like a heat pump by transporting heat from active, warmer muscles to the cooler skin, where it's released through evaporative cooling. Here, the skin acts as a radiator, allowing heat to escape into the environment as sweat evaporates.

Despite these mechanisms, cooling systems have their limitations. In high humidity, the effectiveness of evaporative cooling diminishes, as the saturated air slows sweat evaporation. Similarly, when external temperatures rise, the reduced gradient between core body temperature and the environment lessens the rate of heat transfer. These thermoregulatory principles are reflected in athletic performance data. Analysis of over a thousand World Athletics races identified an optimal performance range at ambient temperatures between 50°F and 63.5°F (Mantzios et al., 2021).

Elevation also plays a critical role in endurance training. Living at high altitudes has been well-documented to increase red blood cell production, enhancing the oxygen-carrying capacity of the blood. This physiological adaptation can significantly benefit endurance athletes. However, training at altitudes that are too high can hinder an athlete's ability to adapt and receive an effective training stimulus. Consequently, the strategy of "living high and training low" has gained popularity, as it allows athletes to reap the benefits of altitude adaptations while performing high-intensity workouts at lower elevations. Yet, opposing evidence also exists, indicating that training at altitude can have unique benefits of its own, leading to ongoing debates in the field (Muraoka & Gando, 2012).

For most non-professional runners, the approach of living high and training high is often more practical than the elite ‘‘live high, train low’’ strategy. This combination can still yield necessary altitude adaptations while facilitating an effective training regimen. Literature suggests that elevations between 1,500 and 3,000 meters are generally suitable for high-level training and adaptation. These altitudes enhance oxygen utilization and improve endurance capacity, ultimately benefiting overall performance (Muraoka & Gando, 2012).

Precipitation, while a less significant factor compared to temperature and elevation, still plays an important role in endurance training. In certain circumstances, rain can enhance evaporative cooling, providing some relief from heat during workouts. However, the downsides of precipitation often outweigh its benefits. Psychologically, rain can be daunting for endurance athletes, creating discomfort and frequently accompanied by challenging wind conditions. Moreover, wet surfaces can reduce traction, increasing the risk of slips and falls. Although this may seem minor, over the course of an hour-long run, the increased demand on stabilizing muscles due to each step becoming slightly more strenuous can accumulate significantly, leading to greater fatigue and potential injury. Again, athletic performance data backs this up. Boston Marthon performance from 1972 to 2018 significantly worsened when conditions were rainy (Knechtle et al., 2019).

Putting this all together, the ideal physical environmental conditions for optimal running performance consist of moderately high elevation complemented by consistently favorable, dry weather, particularly within the temperature range of 50°F to 63.5°F. This study aims to discover which site in the contiguous United States best meets these criteria, offering insights that could enhance training regimens for endurance athletes.

Methodology

This study relies on METAR (Meteorological Aerodrome Report) data, a standardized format for reporting weather conditions at airports and meteorological stations. Originally created for aviation, METAR reports include essential data such as temperature, wind speed, visibility, and precipitation. Many stations have records dating back to the 1940s, making this dataset valuable for historical weather analysis. For our study, we sourced data from the Iowa Environmental Mesonet (IEM), covering 2,223 sites across the contiguous United States over a 30-year period from 1993 to 2023. This dataset provided all essential metrics, including elevation, hourly temperature, and hourly precipitation.

To focus on the most relevant information for endurance athletes, we filtered for daylight hours from 6 AM to 6 PM, the times when athletes are most likely to train. Local time zones were applied for each site to ensure accuracy in assessing running conditions during daylight hours. Only complete years of data were included, which enhanced the reliability of our findings.

Each day was then evaluated to determine if there was at least one hour meeting two conditions: no recorded precipitation and a temperature between 50°F and 63.5°F. Days that met these criteria were counted for each site, and results were averaged across the 30-year period, providing an annualized measure of ideal running weather. I decided to call this variable Ideal Running Days (IRD).

For the normalization of weather and elevation data, two distinct techniques were used. We applied min-max scaling to the weather variables, allowing us to transform them into a standardized range, between 0 and 1, making them easier to compare across locations. The min-max scaling formula is:

$$X' = \frac{X - X_{min}}{X_{max} - X_{min}}$$

where X' is the scaled value, X the original value, and X_{min} and X_{max} the dataset's minimum and maximum values, respectively.

For elevation, we used a linear scaling system to highlight the ideal elevation range for athletic performance, set between 1500 and 3000 meters. Locations within this range were assigned a score of 1, representing optimal conditions. Scores then decreased linearly based on distance from this range. For example, an elevation of 1300 meters would score slightly below 1, proportional to its distance from the minimum threshold of 1500 meters. Likewise, a location at 3200 meters would receive a reduced score, reflecting its distance from the 3000-meter maximum. Scores were bounded to prevent negative values, setting the lowest possible score at zero.

For elevations below 1500 meters:

$$\text{Score} = 1 - \left(\frac{1500 - \text{Elevation}}{1500}\right)$$

For elevations above 3000 meters:

$$\text{Score} = 1 - \left(\frac{\text{Elevation} - 3000}{3000}\right)$$

This method effectively penalizes sites outside the ideal elevation range, ensuring that locations within 1500-3000 meters receive the highest possible scores.

Normalizing the data ensures that all variables contribute equally to the final score, regardless of their original scales and units. After normalizing both the weather and elevation data, we combined these results into a total score for each site, expressed as:

$$S = \text{Ideal Running Days}_{\text{norm}} + \text{Elevation}_{\text{norm}}$$

This system, with each variable normalized and given equal weight, enabled us to compare thousands of sites across the contiguous United States. The resulting scores highlighted locations with the most favorable environmental conditions for running, providing a data-driven approach to identifying ideal training spots for endurance athletes.

Discussion

Our analysis of weather variables highlighted a strong cluster of optimal sites in the Pacific Northwest, particularly in Northern California and Southern Oregon. This region showed a notable dominance in ideal running conditions, with eight sites located in California and two in Oregon. Oceano, California, topped the list, boasting an impressive 361 days per year with ideal running weather. A summary of results for the top locations can be found in the table below.

Site	State	IRD
Oceano	CA	361
Novato	CA	350

Site	State	IRD
Saint Yvez	CA	344
Pentaluma	CA	326
Gold Beach	OR	312
San Martin	CA	312
Creswell	OR	304
Murrieta	CA	303
Travis AFB	CA	302
Hollister	CA	299

Notably, Creswell, Oregon, a suburb of Eugene-often called the "Track Town, USA" for its rich running heritage-is among the top locations with ideal weather for running. Eugene's history as a running hub may well be influenced by its favorable weather conditions, which have supported the city’s longstanding role in American distance running culture.

However, when we looked at elevation as a factor, the leaderboard shifted significantly. Out of 2,223 sites analyzed, 137 locations fell within the optimal elevation range of 1500 to 3000 meters. Key locations that stood out include Colorado Springs, CO, home to the U.S. Olympic & Paralympic Training Center; Alamosa, CO, which hosts Adams State University, a powerhouse in NCAA Division II running; and Flagstaff, AZ, the training base for Northern Arizona University and Hoka's NAZ Elite professional team.

When we combined the elevation and weather scores, New Mexico emerged as the new leader, displacing California from the top of the rankings. Notably, six of the top ten sites were located in New Mexico, with all of the top four positions secured by the state. Moriarty and Gallup, NM, were tied for first, having ideal elevations of 1887 meters and 1972 meters, respectively, along with an impressive average of 285 days of ideal weather each year. This combination of favorable weather and optimal elevation makes these locations particularly appealing for endurance athletes seeking the best training environments. Rounding out the podium was Raton, New Mexico, further solidifying the state's dominance in providing ideal conditions for runners.

Site	State	Elev. (m)	Elev. Score	IRD	IRD Score	Final Score
Moriarty	NM	1887	1	285	.789473684	1.789473684
Gallup	NM	1972	1	285	.789473684	1.789473684
Raton	NM	1939	1	280	.775623269	1.775623269

Site	State	Elev. (m)	Elev. Score	IRD	IRD Score	Final Score
Grants	NM	1988	1	278	.770083102	1.770083102
Window Rock	AZ	2056	1	273	.756232687	1.756232687
Santa Fe	NM	1918	1	269	.745152355	1.745152355
Big Bear City	CA	2062	1	269	.745152355	1.745152355
Silver City	NM	1638	1	266	.736842105	1.736842105
Cortez	CO	1801	1	265	.734072022	1.734072022
Marfa	TX	1476	0.984	268	.742382271	1.726382271

Santa Fe emerges as a potential training hub from this list, as it is part of a larger metropolitan area, which means it offers more resources like access to running stores, athletic clubs, and training facilities. The combination of favorable weather, ideal elevation, and urban amenities creates a conducive environment for both amateur and professional endurance athletes looking to optimize their training regimens.

Looking ahead, future considerations for this analysis could include the proximity to mountains for mountain running training, as elevation and terrain diversity can significantly influence training effectiveness. Additionally, the criteria could be adapted for various outdoor activities, such as snow and cold conditions for skiing. Such flexibility could enhance the usability of the analysis across different sports and environments. I envision developing a web app that integrates these factors, allowing athletes to easily identify optimal training locations based on their specific sport and preferences. This tool could serve as a valuable resource for athletes seeking tailored training environments year-round, making the most of varying seasonal conditions.

Conclusion

The quest for optimal running performance is deeply intertwined with environmental conditions, notably temperature and elevation. This study provides a data-driven framework for identifying locations in the contiguous United States that meet the criteria for effective endurance training. The results demonstrate that while certain areas, such as the Pacific Northwest, excel in ideal weather conditions, New Mexico emerges as a superior training environment when both weather and elevation are taken into account. The analysis underscores the significance of elevating altitude adaptations in enhancing endurance capabilities, thus informing athletes and coaches in their quest for peak performance.

This research lays the groundwork for future explorations into how specific training conditions can be tailored to meet the unique demands of various endurance sports. The potential development of a web application that integrates these findings promises to provide athletes with invaluable resources, facilitating informed decisions about training locations based on environmental factors. Ultimately, this study not only contributes to the ongoing discourse surrounding endurance training but also serves as a practical guide for athletes striving for excellence in their pursuits.

References

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