THE EFFECT OF VENUE ON THE DISTANCE OF A HAMMER THROW

Iain Hunter
Physical Education Department, Brigham Young University, Provo, UT, USA
ian_hunter@byu.edu

INTRODUCTION

In track and field, the hammer can travel over 70 meters and be in the air for over three seconds. While the implement is relatively massive (4 kg for women and 7.260 kg for men), the effects of air resistance and non-constant gravity throughout the earth need to be considered in how the hammer is affected at various venues. As release angle and speed increase, flight time will increase leading to more substantial altitude effects. In a throw of 44 deg that travels a throwing distance of the current men’s world record, the differences due to an increase of 1000 m over sea-level is 55 cm (Mizera & Horvath, 2002).

A computer simulation of a hammer throw similar to that used by Dapena (1982) investigated the effects of gravity and air resistance at a range of venues around the world. With large enough differences, adjustments may need to be made in qualifying for certain meets according to which venue qualifying marks were made.

METHODS

A computer simulation was created to model the path and horizontal distance of the hammer during its flight. The average release velocity and angle used by finalists during 2002 USA Track and Field nationals were used as initial release conditions (Table 1). Release height was set at 1.3m which has been used previously in similar studies (Dapena, 1982). Estimates were made of gravitational accelerations and air densities for University of California Los Angeles, Brigham Young University, Gunnison, CO., Olso, NOR, and Mexico City, MEX for use in the simulation. Since air density varies with temperature, typical high temperatures for the location during July were used.

Table 1: Initial release conditions based upon the average throws of the 2002 USA Track and Field Meet finalists.

<table>
<thead>
<tr>
<th>Release Speed (m/s)</th>
<th>Release Angle (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>26</td>
</tr>
<tr>
<td>Women</td>
<td>25</td>
</tr>
</tbody>
</table>

The simulation took into account characteristics of the hammer, gravitational effects, and air resistance. Atmospheric conditions for the various venues tested were found in the Weather Almanac (Ruffner, 2001) and the acceleration due to gravity was predicted for each venue using equation 1 (Jursa, 1985).

\[
g(m/s^2) = 9.780356 (1 + 0.0052885 \sin^2 \phi - 0.0000059 \sin^2 (2\phi)) - 0.003086H
\]

Equation 1: Prediction of gravitational acceleration based upon latitude and elevation.

where \( g \) is the acceleration due to gravity, \( \phi \) is the latitude in degrees, minutes, and seconds, and \( H \) is the elevation in meters.

RESULTS AND DISCUSSION

Differences were found of up to 0.63 m for women and 0.54 m for men between the most extreme situations of Olso, NOR being the shortest throws and Gunnison, CO. and Mexico City, MEX being the longest (Table 1). Overall, variations in air density account for 70% of the
differences in throws, while gravitational variations make up the other 30%.

The venue differences of 0.63 m and 0.54 m are relatively large considering the differences between athletes throws in competition; for example, the differences between medallists in the 2000 Olympic Games were 1.88 m and 0.85 m for women and men respectively. However, during a given competition, everyone throws under similar conditions, other than perhaps windspeed. While there are benefits to throwing at high altitude, other considerations such as: temperature, wind speed and direction, throwing direction, and other weather conditions should be taken into account before applying any conversions to throwing events by governing bodies of track and field.

Although equal release conditions were used in the simulations, the lower air density may also allow for increased release velocities further increasing the differences between venues.

Table 2: Distances thrown at various venues with the initial release velocities shown in table 1.

<table>
<thead>
<tr>
<th></th>
<th>Men’s Distance (m)</th>
<th>Women’s Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gunnison, CO</td>
<td>66.63</td>
<td>62.00</td>
</tr>
<tr>
<td>Los Angeles, CA</td>
<td>66.34</td>
<td>61.64</td>
</tr>
<tr>
<td>Mexico City, MEX</td>
<td>66.71</td>
<td>62.06</td>
</tr>
<tr>
<td>Oslo, NOR</td>
<td>66.17</td>
<td>61.43</td>
</tr>
<tr>
<td>Provo, UT</td>
<td>66.54</td>
<td>61.83</td>
</tr>
</tbody>
</table>

**SUMMARY**

Substantial differences are found between venues due to the differences in gravitational acceleration and air density, assuming similar release conditions. While the differences shown here appear to provide an advantage to throwing at relatively high altitude and certain latitudes, considerations of competition level at the meet, weather conditions for the day and time of day, and wind speed and direction.

**REFERENCES**