EFFECTS OF WINDS ON WORLD CLASS LONG JUMP PERFORMANCE

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INTRODUCTION

Since 1936 there has been a rule in athletics applied to the sprints, hurdles and horizontal jumps regarding the maximum wind assistance for record purposes. The value of this has been $+2ms^{-1}$ although there has been considerable debate about the magnitude of the effects of winds on performance. Most studies have focused on the men's 100m and there is a great deal of statistical evidence here (e.g. Dapena & Feltner 1987 and Linthorne 1994) that athletes do not gain the full benefit of wind assistance predicted in theoretical analyses.

Some theoretical studies have been done on Bob Beamon's famous, 1968 World record long jump (Brearley 1977, Burghes et. al. 1982, Frohlich 1985 and Ward-Smith 1986). Also, Ward-Smith (1983 & 1985) has produced a mathematical model of the effects of wind assistance on long jump performance. Rottenberg (1979) proposed that a conversion table should be developed for the horizontal jumps, but this has not been done so far. The aim of this study is to determine the effects of wind on long jump performances from statistical information of official competitions. These can then be compared to theoretical studies and the advantage of a $+2ms^{-1}$ wind determined. From ongoing analyses of actual competition performances, a computer program is being developed for converting world class performances in known wind conditions to equivalent performances in still air for all the relevant track and field events.

METHOD

Athletic competition undertaken in controlled conditions and with accurate measurement are a useful source of data. In this study the effect of wind velocity is quantified by examining the performances of a World class performer in varied wind conditions. Quadratic regression analysis, using the least squares method, and extrapolation, were applied to the best, non-altitude, long jump performances of Carl Lewis (n = 20, mean 8.69m, St. Dev. 0.06), in known wind conditions (range $-0.04ms^{-1}$ to $+4.6ms^{-1}$ mean $1.43ms^{-1}$, St. Dev. 1.50) Carl Lewis was unbeaten at long jump for ten years from 1981 and the performances analysed were 20 of the top 30 long jumps in history, prior to the 1991 World Championships.

Analysis was also carried out on the best, non-altitude, long jump performances of Heike Drechsler during her peak from 1984 to 1988, (n = 16, mean 7.37m, St. Dev. 0.06) with wind speeds of (range $-0.02ms^{-1}$ to $+3.5ms^{-1}$ mean $1.42ms^{-1}$, St. Dev. 1.03). Drechsler held 18 of the top 31 world performances, including 3 of the top 5 wind assisted performances and the 2 top indoor performances upto 1991.

RESULTS

The analysis of Lewis's performances produced the following findings.

Wind adjustment can be expressed as $\mathbf{S_s = S_c - 0.031w + 0.0027\ w^2}$,

where S_s = distance achieved in still air, S_c = distance recorded in competition and w = recorded wind speed.

The standard error of the estimate (S.E.) = 0.05.

The legal wind limit of **+2ms^{-1}** gives an improvement in performance of **0.05m** (0.6%).

The rate of improvement gradually decreases with increasing wind velocity.

From the equation the optimum wind assistance is **+5.5ms^{-1}**.

A wind of **+5.5ms^{-1}** gives an improvement in performance of **0.09m**.

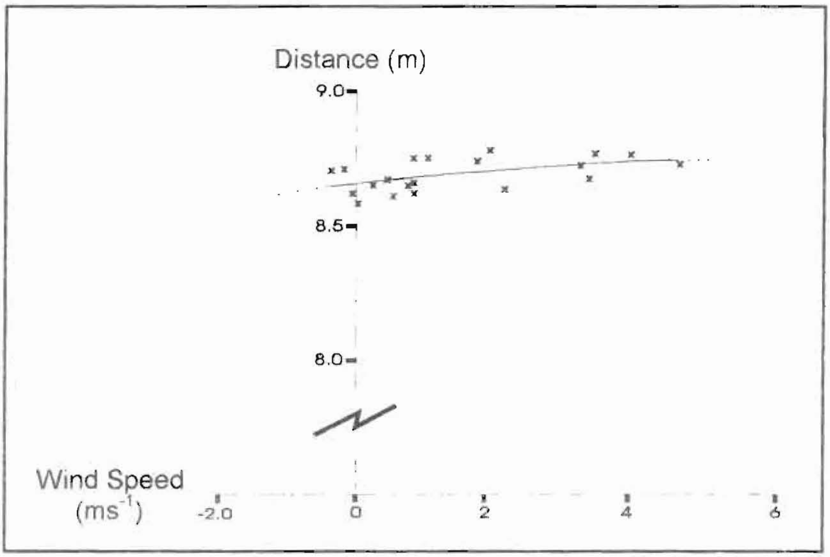
Above **+5.5ms^{-1}** the improvement in performance decreases and, if the quadratic relationship holds, this would be 0 at +11.5ms^{-1}.

A wind speed of +9.5ms^{-1} would give the same performance advantage as a wind speed of +2ms^{-1}.

Winds above +11.5ms^{-1} would be a detriment to performance.

These results show similar levels of effects to analyses of Carl Lewis's 100m and 200m performances.

Scattergram and Line of Best Fit, Quadratic from Carl Lewis's Data.



Similar analysis of Heike Drechsler's performances revealed,

Wind adjustment is expressed as $\mathbf{S_s = S_c - 0.049w + 0.016\ w^2}$ (S.E. 0.06)

The legal wind limit of **+2ms^{-1}** gives an improvement in performance of only **0.03m** (0.4%).

Brearley (1977), Burghes et al. (1982), Frohlich (1985) and Ward-Smith (1986) indicate similar results for calculating the altitude effect on the aerial phase of the long jump, at approximately 0.01m per 1000m. Further, Ward-Smith (1986), has calculated that the effect of altitude on run-up speed leads to an improvement in world class long jumping of 0.06m per 1000m. Also, that a $+2ms^{-1}$ wind velocity during the aerial phase increases the jumping distance by 0.03m.

The 8.90m jump by Bob Beamon in Mexico City (altitude 2250m) with a recorded wind speed of $+2ms^{-1}$ was calculated as being enhanced 0.27m by Frohlich (1985) and 0.31m by Ward-Smith (1986). Consequently, a $+2ms^{-1}$ wind in a long jump at sea-level is expected in theory to increase the distance jumped by approximately 0.12m and 0.16m (1.4% & 1.8%) respectively.

A direct relationship between assisting wind speed and improvement in performance has been demonstrated with actual competitive performances of the top male and female long jumpers of the 1980`s, however, the effects of wind velocity on performances in competition were found to be approximately one third of the effects predicted by Ward-Smith (1986). The reasons for this may be i) an oversimplification of the drag area and drag coefficient in the theoretical models ii) winds causing inaccuracies in the athletes run-up, and/or a systematic error in wind measurement.

At the 1991 World Championships in Tokyo, Carl Lewis broke the World record for the 100m and, in the long jump, was the first person to surpass Bob Beamon`s 1968 World mark. Lewis`s 6 trials in the final achieved 4 of the 7 longest jumps in history, but he was still beaten in this competition by Mike Powell who produced the current World record long jump of 8.95m. The table below indicates how the top performances change after applying the adjustment equation derived from this study.

<u>THE TOP TEN LONG JUMPS TO 1992</u>

Recognised Rank			**Wind Speed**	**Distance**		**Wind Adjusted**
2	1968, Beamon		$+2.0ms^{-1}$	**8.90m**	(altitude)	8.85m (3)
6	1983, Lewis		$+1.9ms^{-1}$	8.79m		8.72m (9)
	1984, Lewis		*(indoor)*	*8.79m*		8.79m (7)
	1985, Lewis		$+3.9ms^{-1}$	8.77m		8.69m
4	1987, Emmiyan		$+1.9ms^{-1}$	8.86m	(altitude)	8.81m (5)
	1987, Lewis		$+3.4ms^{-1}$	8.77m		8.70m (10)
	1991, Lewis	(Tokyo)	$+2.3ms^{-1}$	8.83m		8.77m (8)
	1991, Lewis	(Tokyo)	$+2.9ms^{-1}$	**8.91m**		8.84m (4)
1	**1991, Powell**	**(Tokyo)**	$\mathbf{+0.3ms^{-1}}$	**8.95m**	**(W.R.)**	**8.94m (1)**
3	1991, Lewis	(Tokyo)	$-0.2ms^{-1}$	8.87m		8.88m (2)
5	1991, Lewis	(Tokyo)	$+1.7ms^{-1}$	8.84m		8.80m (6)

Heike Drechsler's performances exhibit a similar pattern but less consistency and less advantage from wind assistance, than those of Lewis. In respect of consistency they are similar to statistical analyses of women's sprint performances. Linthorne (1994) deduced that the increased advantage from wind assistance for women in the 100m was as a result of the longer time that the wind was acting over the race despite slower running speeds. This is not necessarily the case in long jumping.

CONCLUSION

The study provides a statistical analysis of data from official long jump competitions with particular reference to the performances of Carl Lewis. A distance adjustment equation is presented from the quadratic regression analysis and the results give further evidence that athletes are not able to take full advantage of the expected assistance provided by following winds in track and field athletics. The advantage from a $+2ms^{-1}$ wind is calculated as 0.05m.

A computer program, to run under the Microsoft Windows environment, for converting performances to equivalent times in still air for the men's long jump, 100m and 200m has been developed from Lewis's best performances when at his peak between 1981 and 1989. Further analyses of other World class long jumpers is being undertaken to confirm the relationship between wind speed and distance jumped.

REFERENCES

Brearley, M.N. (1977) The long jump miracle of Mexico City. In Optimal Strategies in Sports (edited by S.P. Ladany and R.E. Machol). Amsterdam: North Holland Publishing Company.

Burghes, D.E., Huntley, I and McDonald, J (1982) Applying Mathematics (pp. 91-97). Chichester: Ellis Horwood.

Dapena, J. and Feltner, M.E. (1987) Effects of wind and altitude on times of 100m sprint races. International Journal of Sports Biomechanics, 3, 6-39.

Frohlich, C. (1985) Effect of wind and altitude on record performances in foot races, pole vault and long jump. American Journal of Physics, 53, 726-730.

Linthorne, N. (1994) The effect of wind on 100m sprint times. Journal of Applied Biomechanics, 10, 110-131.

Rottenberg, P.A. (1979) Revision of current I.A.A.F. wind speed rules, International Technical Symposium World Cup II Documentation. International Amateur Athletic Federation.

Ward-Smith, A.J. (1983) The influence of aerodynamic and biomechanical factors on long jump performance. Journal of Biomechanics, 16, 655-658.

Ward-Smith, A.J (1985) The influence on long jump performance of the aerodynamic drag experienced during the approach and aerial phases. Journal of Biomechanical Engineering, 107, 336-340.

Ward-Smith, A.J. (1986) Altitude and wind effects on long jump performance with particular reference to the world record established by Bob Beamon. Journal of Sports Sciences, 4, 89-99.