

“Javelins: throwing, training and associated injuries”

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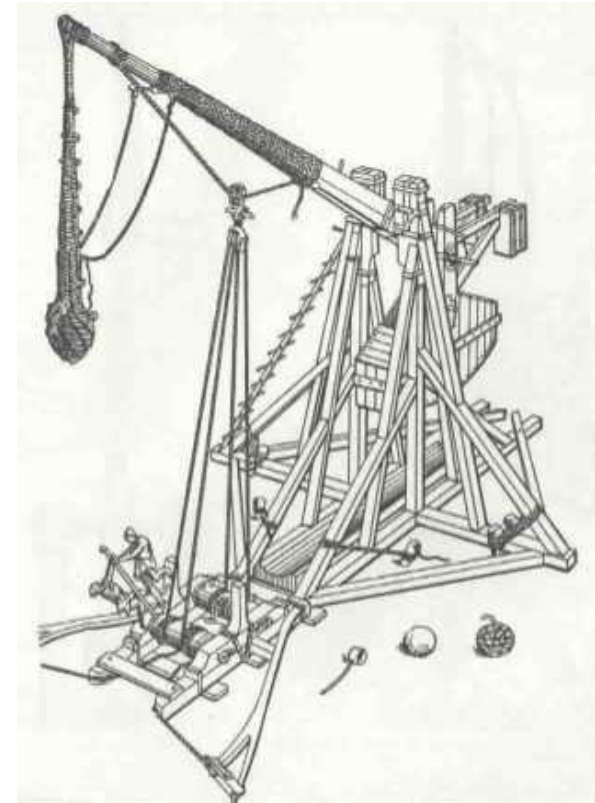
Background



- Ancient artillery
 - Ballistas and other projectile throwers
 - The war-bow
 - Javelin (much lighter than spear)

Background – siege engines

- Siege engines
 - Trebuchets and other projectile throwers.



<http://www.aemma.org/training/trebuchet/trebuchetTraining.htm>

Background



- The war-bow
 - Nowadays known as the long-bow
 - Mary Rose bows had draw-weights in the range 100-185 lbf (445 - 820 N)
 - Could cast an arrow 250m, (practice less than 200m was forbidden by Henry VIII)
 - Could penetrate much of the armour of the time at 100m using the bodkin, (the fore-runner of armour-piercing missiles).

Background

- The war-bow
 - It will typically penetrate a four inch oak door with a handspan of the shaft exposed on the far side.
 - 1000 arrows a second at Agincourt



<http://www.history-magazine.com/longbow.html>

Background

- The javelin
 - Evolved from the throw spear.
 - 800gm and 2.6-2.7m long
 - Rebalanced after Uwe Hohn increased world record to 104.80m
 - Current record is 98.48m by Jan Zelezny.



http://en.wikipedia.org/wiki/Javelin_throw

Overview



- Throwing
- Training
- Injuries



Throwing – great throwers of the past

Steve Backley (GBR)

Uwe Hoehn (GER)

Jan Zelezny (CZE)

Video kindly supplied by Brian Parkes, UKA level 4 javelin coach



Training the next generation

A young thrower in a training session ...

Parameters:-

- Distance: ~ 70m.
- Release speed: ~ 27m./s.
- Flight duration ~ 5s.
- Max height ~ 26m.
- Athlete, 1.91m, 100kg

With the same parameters and biomechanics, another 3m/s release speed is necessary to reach ~87m.

Video kindly supplied by Brian Parkes, UKA level 4 javelin coach

A bit of science can help



- No previous work on the effect of wind
- 1cm is enough to win or lose in 90m
- The javelin is significantly affected by wind

Folklore



Headwind

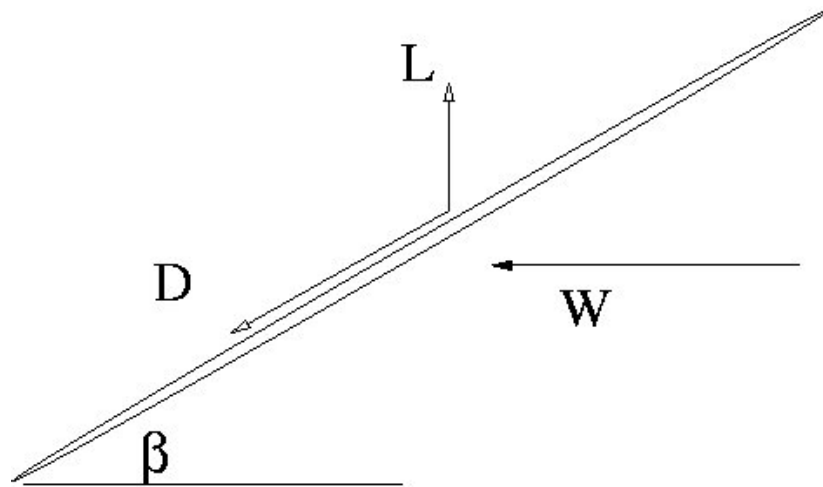
Tailwind

Modelling - assumptions



- No 3-D effects, (an athlete's best throws tend to be 2-dimensional)
- Axial rotation ignored, (although it can be as high as 25 revs/s)
- Javelin does not flex

Forces acting on a fixed aerofoil due to a horizontal wind



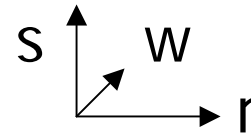
Thin fixed aerofoil in a horizontal wind:

- The lift is L is due to inviscid effects, (no drag).
- D is a drag term for viscous effects

The model



The vertical equation looks like ...



$$m \frac{d^2 s}{dt^2} = -mg$$

Gravity

$$+ 4\pi\rho \left(\frac{dr}{dt} + U \cos \psi \right)^2 \sin(\theta + \alpha)$$

Lift

$$- 2\gamma\rho \left(\frac{dr}{dt} + U \cos \psi \right)^2 \sin(\theta + \alpha) \{ \pi \varepsilon^2 + 4L\varepsilon \cos \alpha \}$$

Drag 1

$$- 2\gamma\rho \left(\frac{ds}{dt} \right)^2 \sin(\theta + \alpha) \{ \pi \varepsilon^2 + 4L\varepsilon \cos \alpha \}$$

Drag 2

... Solved as coupled non-linear odes

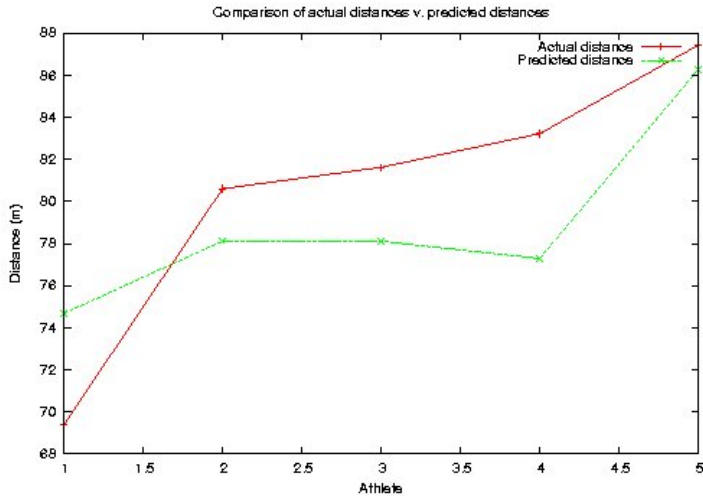
Qualitative behaviour



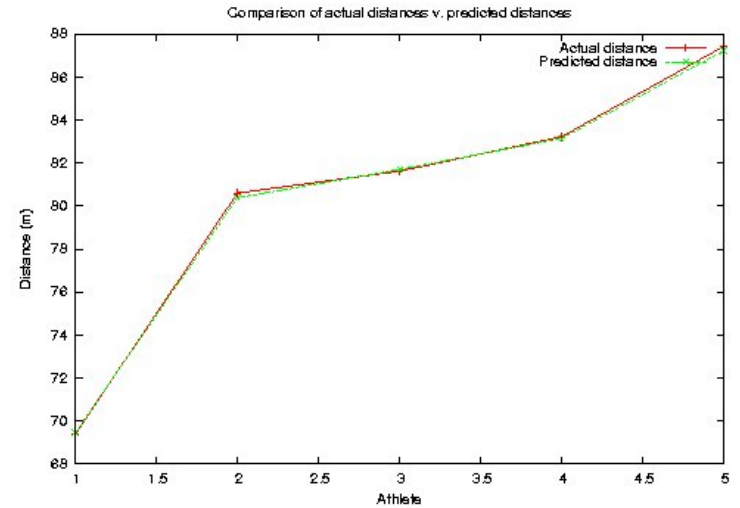
- Solving these equations gives good qualitative agreement with the observed flight of javelins

Demonstrate ...

1991 World Student Games

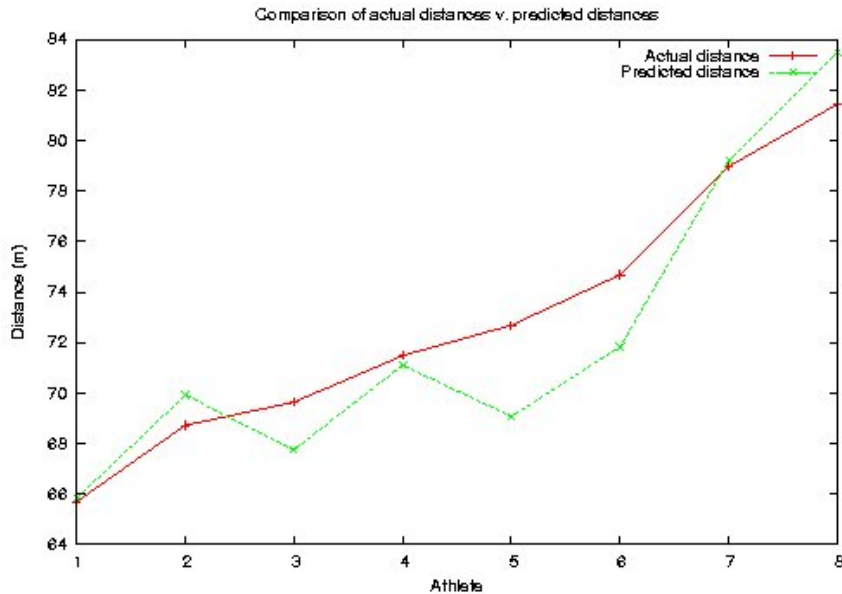


Assumption of no wind

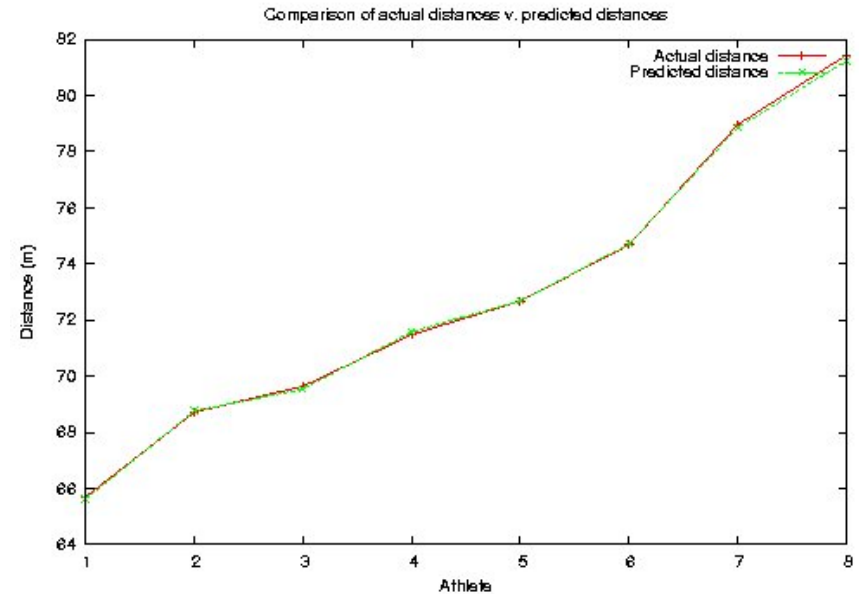


Assumption of gentle tail wind

BAF 1993 Championships



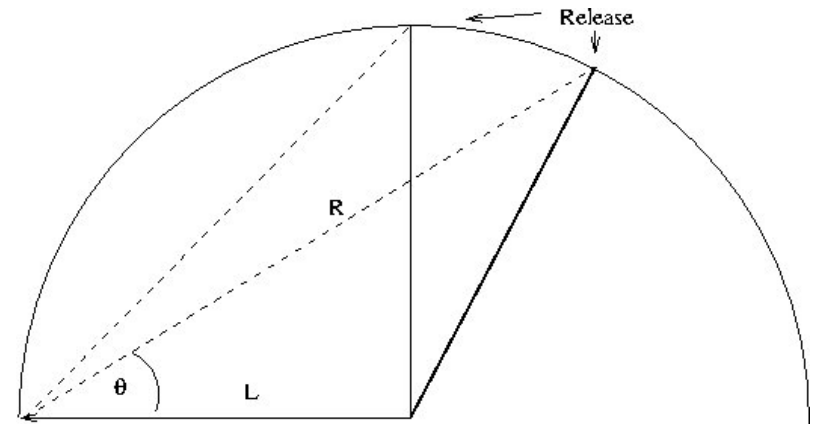
Assumption of no wind



Assumption of gentle variable but mostly head wind

Influence of biomechanics

It is observed that as the angle θ decreases, velocity of delivery increases at around 0.13m/s/degree



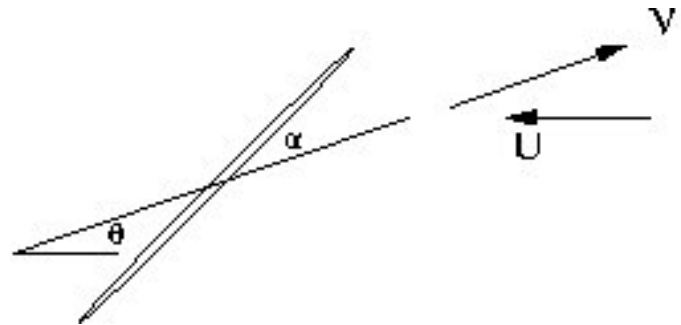
For acceleration a , as the angle θ decreases, the length of pull increases giving

$$V = \sqrt{4aL \cos \theta} \quad \sim 0.12 \text{ m/s/d}$$

Optimal searching

- Given a wind direction and strength, and athlete biomechanics, what is the optimum
 - Attack angle α ?
 - Delivery angle θ ?

Simulate ...



Overview



- Throwing
- Training
- Injuries

Training



■ Emphases

- Strength: Cleans 140-150Kg, Squats 250Kg+
- Bounding: Standing long jump > 3m.
Standing three jumps > 10m
- Sprints: 11.0-11.5 100m
- Gymnastic ability

Training - weights



■ Emphases

- Similar pattern as other throws through winter. Pullovers much more important than bench.
- Summer, 1 heavy weights throughout season to keep strength.
- As much med ball as you can take.

Training - technique



■ Emphases

- Run-up must be fluid, accelerating with great hip flexibility.
- Bounding. Huge leg strength required – greater even than triple jumper with similar ankle and knee stability requirements.

Overview



- Throwing
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- Injuries

Injuries

- Most vulnerable (in roughly decreasing order)
 - UCL and elbow soft tissue
 - Shoulder. Rotator cuff takes fearful battering
 - Adductors
 - Plant leg (4 times body weight), ankle, knee and lumbar back.
 - Abdomen (occasional), neck.
- Technique and core strength are key

Other information



For more information and downloadable papers see:-

<http://www.leshatton.org/>