Javelin Throwing Technique and Biomechanics

Riku Valleala
KIHU – Research Institute for Olympic Sports

Athletics Coaches Seminar, 6-8 November 2015, Oslo
Contents of this presentation

• Basics of biomechanics in javelin throwing
• Importance of the release speed
• Factors affecting to release speed
  – Based on research findings
• Conclusions
Information based on…

- KIHU 1991-1999 Finnish throwers
  - Around 250 throws analyzed
- KIHU 2006-2015 Finnish throwers
  - Totally 753 throws
- KIHU’s analysis in Helsinki EC 2012
- Other competitions from 1984-
- A review from many studies, than just believing in one analysis!
- Not too many good competition analyses from latest years available.
Javelin throwing

• Very complex performance having several variables, which all affect to the throwing distance

• Same result can be achieved with many different techniques or styles

• [https://www.youtube.com/watch?v=qVO89xE8o1I&list=PL9raFAO5De5SsDsDy1NyoDvaVBYYmWKq9](https://www.youtube.com/watch?v=qVO89xE8o1I&list=PL9raFAO5De5SsDsDy1NyoDvaVBYYmWKq9)
Factors affecting throwing distance

Release parameters
- Release speed
- Release angle
- Release height
- Release angle of attack
- Release angle of side-slip
- Release pitching moment

Aerodynamic factors
- Javelin
- Wind
- Gravitation

Modified from:
- Hay, 1993
- Morriss and Bartlett, 1996
Release speed

• Release speed is the strongest factor affecting flight distance

• There are several results of high correlations between release speed and throwing distance
  - Viitasalo & Norvapalo 2003 $r = .75$
  - Helsinki 2005 $r = .89$
  - Osaka 2007 $r = .94$
  - Berlin 2009 $r = .67$
  - KIHU 2006-2015 $r = .91$
Release speed

Finnish throwers 2006-2015 (MEN, n=271)

\[ R^2 = 0.7973 \]
Components of release speed

Release speed = Work applied to the javelin

20-30 % of final release speed

Thrower’s approach speed

Ground reaction forces

70-80 % of final release speed

Force generated by muscles

Pulling distance

Support leg actions

Hip/Shoulder rotation

Muscle coordination

etc.
Components of release speed

- What is needed to accelerate javelin up to 30 m/s delivery phase?
  - about 20 kg average force to javelin
  - in 0.100 seconds
  - for distance of 1.80 m
  - with an average acceleration on 240 m/s
- Work about 350 J
- Power 3500-4000 W
Components of release speed

• Release speed is the strongest factor, so…
• It is reasonable to compare different variables to release speed instead of throwing result, because…
• There are many independent factors affecting to throwing result after javelin releases from the hand.
Run-up speed (approach speed)
Run-up speed (approach speed)

• Some values for MEN (at the final foot contact)
  – Los Angeles 1984  5,3 m/s  (finalists)
  – Barcelona 1992   5,2 m/s  (finalists)
  – Göteborg 1995    5,9 m/s  (finalists)
  – KIHU 1991-1999   5,7 m/s  (mean ~81 m)
  – Helsinki EC 2012  5,7 m/s  (mean ~79 m)
  – KIHU 2006-2015   5,9 m/s  (mean ~79 m)

• …and for WOMEN (at the final foot contact)
  – Los Angeles 1984  5,4 m/s  (finalists)
  – Barcelona 1992   5,6 m/s  (finalists)
  – KIHU 1991-1999   4,7 m/s  (mean ~59 m)
  – KIHU 2006-2015   5,0 m/s  (mean ~54 m)
Run-up speed vs. throwing distance

• Connections to throwing result?
  – Igekami et al 1981 no correlation
  – Lon Angeles 1984 no correlation
  – Helsinki WC 2005 $r = .74$
  – Osaka 2007 $r = .59$
  – KIHU 2006-2015 no correlation
  – Helsinki EC 2012 $r = -.44$
Run-up speed vs. throwing distance

- Helsinki WC 2005 + (Japanese ones):

![Graph showing the relationship between run-up speed and throwing distance. The correlation coefficient is r = 0.742 ***.](image)

Murakami et al. 2006
Run-up speed vs. release speed

- Helsinki EC 2012 men finalists:

$r = -.56$
Run-up speed vs. release speed

- Finnish throwers 2006-2015, men

![Bar chart showing run-up speed vs. release speed for Finnish throwers 2006-2015, men. The chart compares speeds at final foot contact and at release. At final foot contact, the speeds for 24-26.5 m/s are 4.9 m/s and for over 27.5 m/s are 5.7 m/s. At release, the speeds for 24-26.5 m/s are 2.8 m/s and for over 27.5 m/s are 3.3 m/s.]}
Run-up speed vs. release speed

- German analyses

F. Lehmann, 2014
Ground reaction forces at delivery phase

- PEAK (max force)
- "ACTIVE force"

Graph showing:
- Knee angle
- Vertical force
- Horizontal force
- Lateral force

Timeline from 1 ms to 451 ms with peaks labeled 1, 2, and 3.
Ground reaction forces and release speed

- Maximal vertical force vs. proportional release speed

Korjus 1988
Ground reaction forces and release speed

- Finnish throwers 2011-2012 (vertical force measured with pressure insoles, in trainings):

![Bar chart](chart.png)

- Brace leg PEAK
  - 24-26.5 m/s: 5084 N
  - over 27 m/s: 5399 N

- Brace leg ACTIVE
  - 24-26.5 m/s: 2481 N
  - over 27 m/s: 3107 N
Knee angle of the support leg
Knee angle of the brace leg

- Often considered as an important factor
- Helsinki EC 2012 men finalists ($r = .46$):
Knee angle of the brace leg

- Helsinki WC 2005 (+ Japanese throwers), men:

[Graph showing the relationship between fore leg knee angle and throw distance with a linear trend line and correlation coefficient r = 0.319*]

Murakami et al 2006
Knee angle of the brace leg

**Berlin WC 2009**
- Brace leg knee angle 0.06 s after the touch down for male throwers:
  - Average for places 1-3: 156 degrees
  - Average for places 4-11: 145 degrees

**Sevilla WC 1999**
- Brace leg knee angle for male throwers
  - 1 = at touch down
  - 2 = minimum
  - 3 = at release

![Bar chart showing knee angles for different places and knee angles](chart.png)
Pull distance
Pull distance

- Traditionally: longer pull distance $\rightarrow$ higher release velocity
- Pull distance vs. throwing distance or release speed
  - Helsinki WC 2005, men: no correlation
  - Osaka 2007, men: no correlation
  - Helsinki 2012, men: $r = .72$ (release speed)
  - KIHU 2006-2015: no correlation
- Antropometrics will affect in some extend to this variable.
Pull distance vs. release speed

- Helsinki WC 2005 (+ Japanese throwers), men:

![Graph showing the relationship between pull distance and throw distance with a correlation coefficient of r = 0.426 **](image)

Murakami et al 2006
Pull distance vs. release speed

- Helsinki EC 2012 men finalists:

![Graph showing the relationship between pulling distance and release velocity with a correlation coefficient of r = 0.72](image-url)
Duration of the final step

• Higher run-up velocity -> shorter duration
• “Try to get your front leg to the ground as fast as possible”
• Correlations quite conflicting:
  – Osaka 2007, men no correlation
  – KIHU 2006-2015 no correlation
  – Helsinki EC 2012, men $r = .55$
Duration of the final step and release speed

- Finnish throwers 2006-2015:
- Helsinki EC 2012:
Duration of the two last steps

- Long cross-over + shorter final step
- Finnish throwers 2006-2015, men:

![Bar chart showing duration of cross-over and final step for different speeds.](chart.png)
Duration of the two last step

- Berlin WC 2009 men finalists
Hip and shoulder rotation angles

- Rotation of the hip axis and shoulder axis viewed from above

Throwing direction (right-handed thrower)
Hip and shoulder rotation angles

• Berlin WC 2009 men, places 1-3 vs. 4-11:

Hip rotations at final foot contact, places 1-3 vs. 4-11:
99 vs. 110 (men), 82 vs. 107 (women)
Release point of the javelin

• Distance between the release point and toes of the front leg in horizontal direction
Release point of the javelin

- Helsinki EC 2012 men finalists:
Release point of the javelin

• Finnish male throwers 2004-2012:
  -0.20
  -0.15
  -0.10
  -0.05
  0.00

Release point

-0.19
-0.15

m

24-26,5 m/s
over 27,5 m/s
Conclusions

• It can be proposed that better throwers
  – Have greater approach speed
  – Have longer cross-over step, but short final step
  – Have bigger pull distance
  – Have stiffer support leg
  – Produce higher ground reaction forces
  – Start hip rotation earlier and rotate their shoulder axis more at the end of pull phase
  – Release javelin further on the front (closer to the toes of support leg)
Conclusions

• Group-level correlations give some fundamentals for improving performance.
• BUT there are also other variables that may be important at individual level.
• And, the higher level of an athlete, the more individual based analysis should be.
Thank you!