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Biomechanical Factors of Throwers Actions in Javelin

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Javelin throwing

- Very complex performance having several small and larger details and variables, which all affect to the throwing distance
- Same result can be achieved with different techniques or even with different biomechanical ways to do the same thing
- However, there are a group of factors that have been shown to have connections to the throwing result in a larger group of throwers or at individual level
- Let's go through some of these factors…

Optimal throwing technique?

Factors affecting to throwing distance

- Throwing distance
  - Release parameters
    - Release speed
    - Release angle
    - Release angle of attack
    - Release angle of yaw
    - Release pitching moment
  - Aerodynamic factors
    - Javelin
    - Wind
    - Gravitation

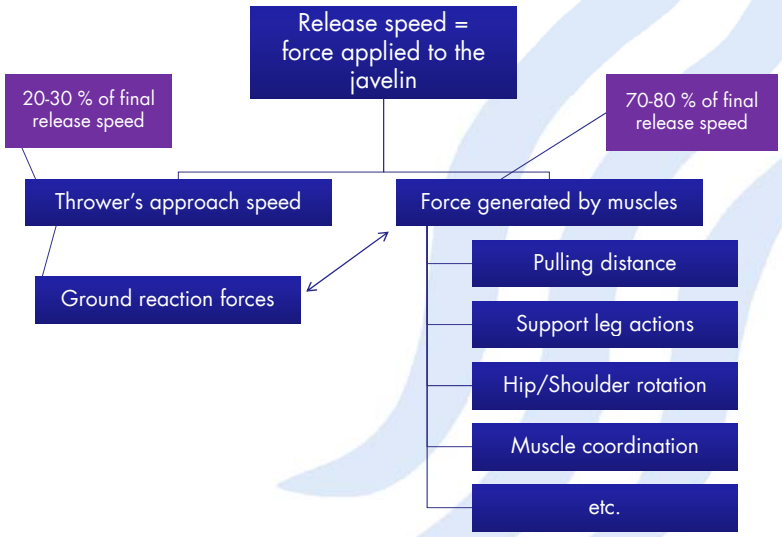
Modified from:
- Hay, 1993
- Morriss and Bartlett, 1996

Release speed

- Release speed is the strongest factor affecting to 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
    KIHU 2008 r = .78 (M), r = .86 (W)
- So, the question is…

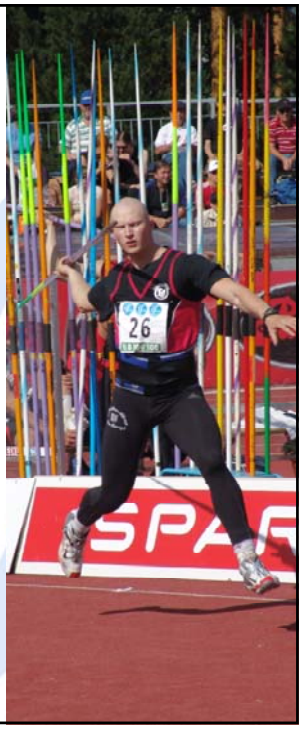
How to maximize release speed with the given individual?

What makes "release speed"



Run-up speed (approach speed)

- Usually speed is highest at the start of delivery step and decreases after that
- The goal: High, but optimal horisontal speed at final foot strike
  - Speed should be in relation to one's throwing technique
- Provides an initial velocity for the javelin followed by a muscular acceleration in delivery phase



Run-up speed (approach speed)

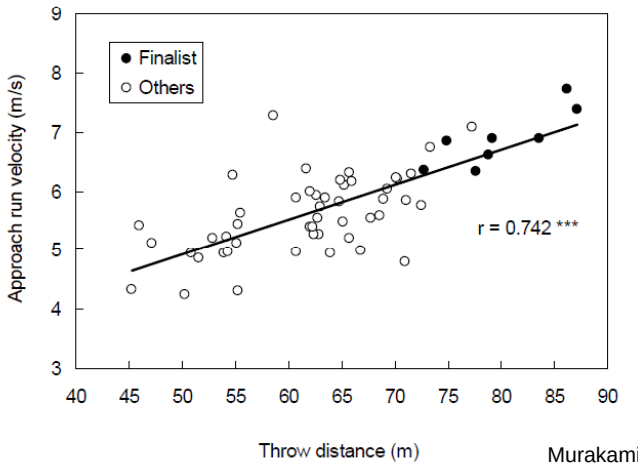
- Some values for MEN (at the final foot contact)
  - Los Angeles 1984 5,3 m/s (finalists)
    Barcelona 1992 5,2 m/s (finalists)
    Göteborg 1995 5,9 m/s (finalists)
    KIHU 1991-1999 5,7 m/s (mean ~81 m)
    KIHU 2008 5,9 m/s (mean ~80 m)
- …and for WOMEN (at the final foot contact)
  - Los Angeles1984 5,4 m/s (finalists)
    Barcelona 1992 5,6 m/s (finalists)
    KIHU 1991-1999 4,7 m/s (mean ~59 m)
    KIHU 2008 4,4 m/s (mean ~55 m)

Run-up speed (approach speed)

- Connections to throwing result?
  - Igekami et al 1981 — no correlation
    Lon Angeles 1984 — no correlation
    Helsinki 2005 — r = .74
    Osaka 2007 — r = .59
    KIHU 2008, men — r = .53

Run-up speed vs. throwing distance

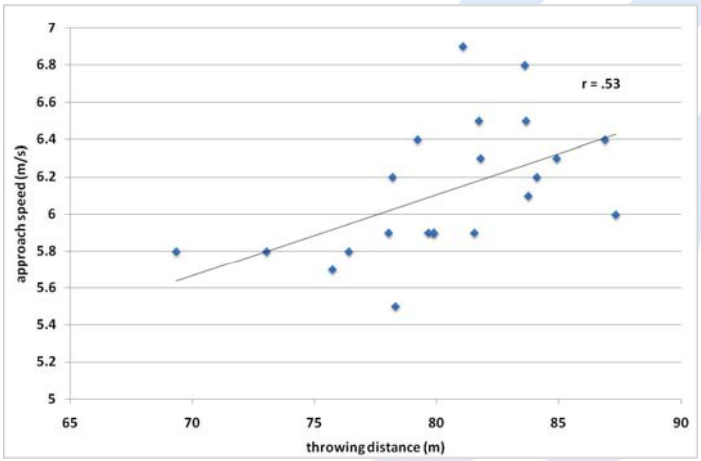
Male throwers (Helsinki 2005 + Japanese ones):



Murakami et al 2006

Run-up speed vs. throwing distance

Male throwers (KIHU 2008):



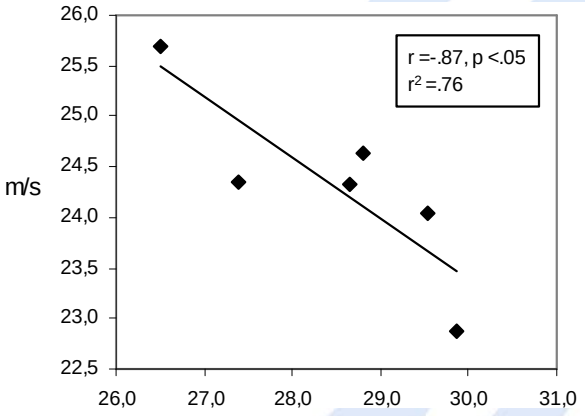
Body posture at the start of delivery step

Body posture at the start of delivery step

- Quite often discussed detail of throwing technique
- "Upper body should not lean backwards too much"…
- The main focus should be in a quick transfer from right leg to the left (delivery) leg
- No statistical connections to throwing distance at group level

Body posture at the start of delivery step

Backwards lean of the body vs. release velocity in one individual



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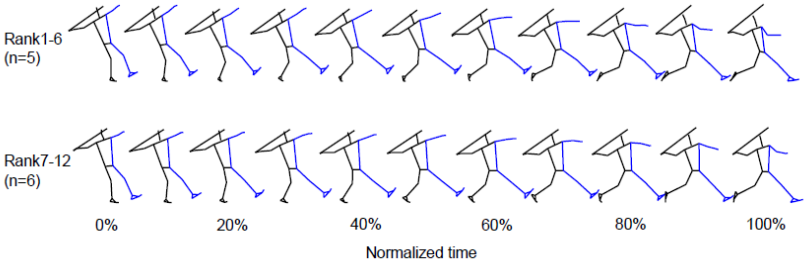
Knee angle and actions of the right leg

Knee angle and actions of the right leg

- Fairly new factor brought out having some effect on delivery phase
- Related to the ability of "hitting the hip"
- Interesting founding from Tauchi et al. in Osaka 2007 analysis
  - Better throwers have more flexion at the rigth knee in preparatory phase
  - "Knee down and inside" –motion was performed that way perhaps more efficiently

Knee angle and actions of the right leg

Male throwers (Osaka 2007):

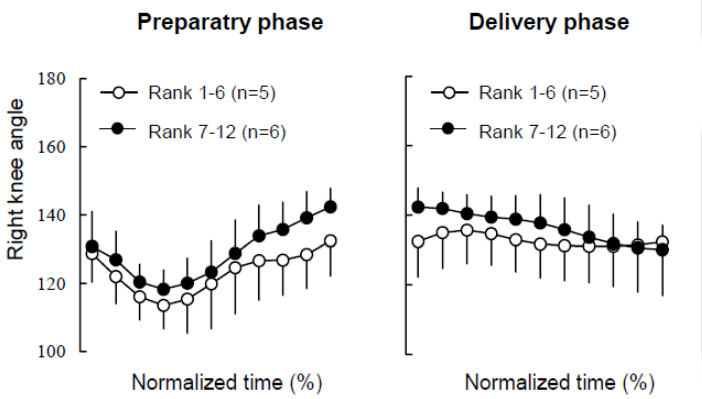


Averaged stick figures of the motion during preparatory phase

Tauchi et al 2007

Knee angle and actions of the right leg

Male throwers (Osaka 2007):



Tauchi et al 2007

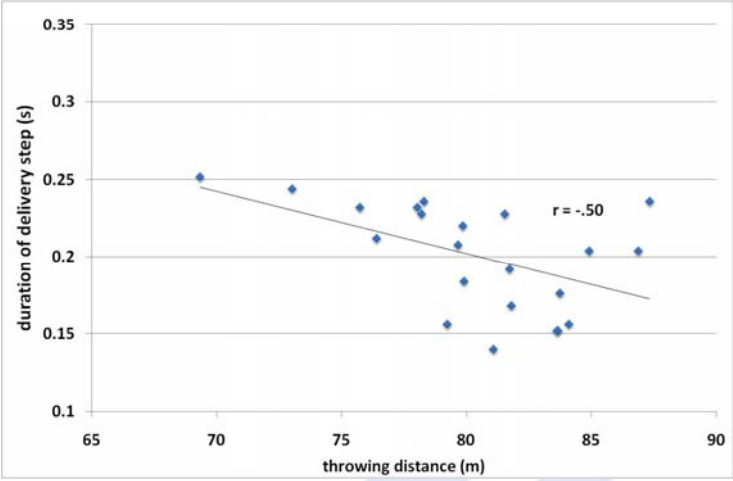
Duration of the delivery step

Duration of the delivery step

- Higher run-up velocity -> shorter duration
- Tend to be shorter on duration in better throws
- Some values from the studies
  - Osaka 2007, men 0.19 s
    KIHU 2008, men 0.21 s
    Barcelona 1992, men 0.22 s
    Barcelona 1992, women 0.21 s
- Correlations to throwing result?
  - Osaka 2007, men no correlation
    KIHU 2008, men r = -.50
    KIHU 2008, women r = -.35

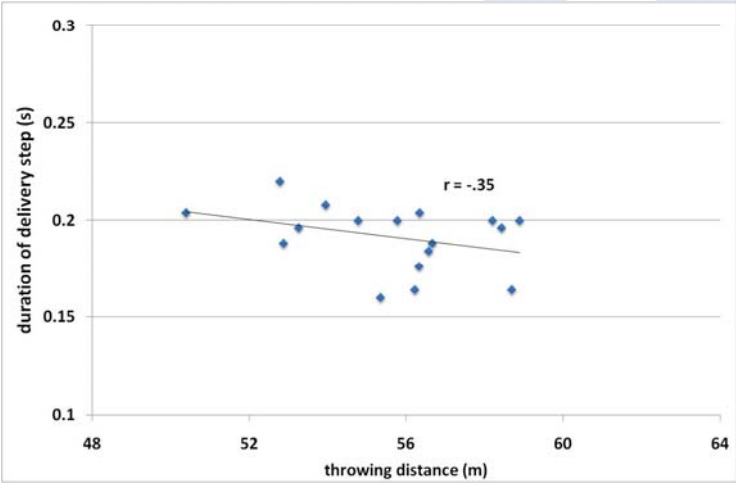
Duration of the delivery step and result

Male throwers (KIHU 2008):

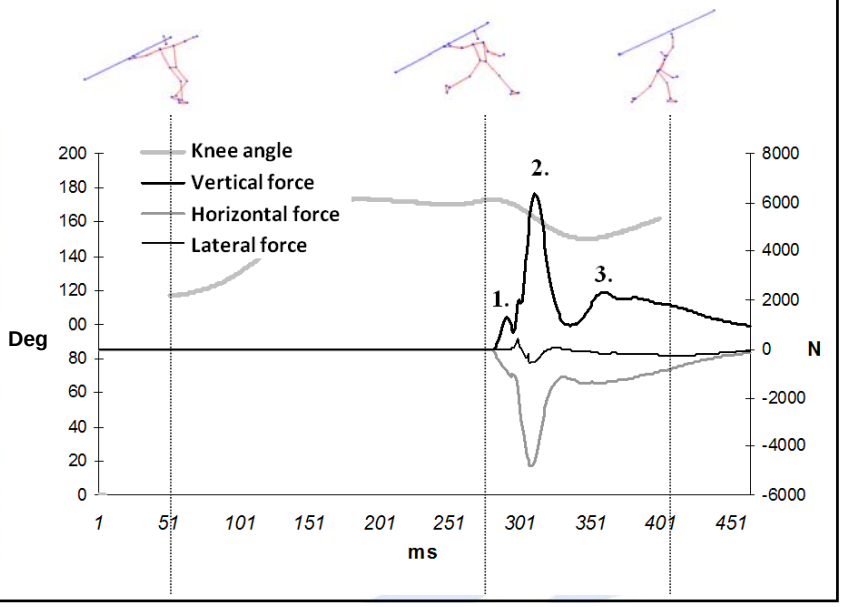


Duration of the delivery step and result

Female throwers (KIHU 2008):

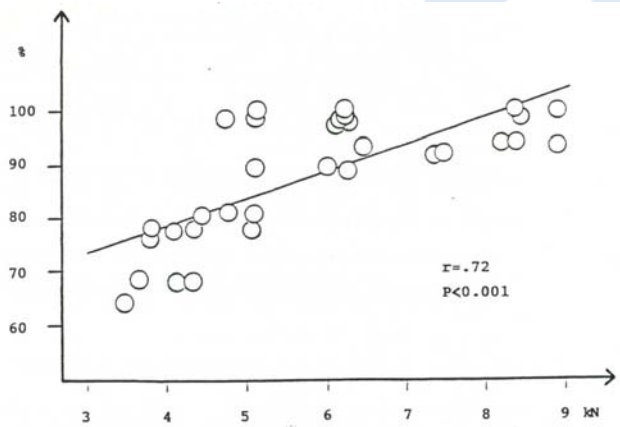


Ground reaction forces at delivery phase



Ground reaction forces and release speed

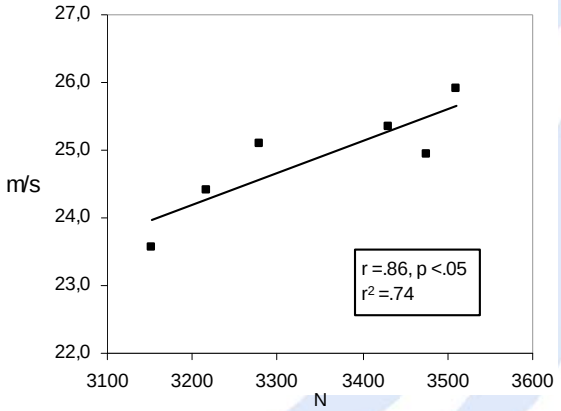
Maximal vertical force vs. proportional release speed



Korjus 1988

Ground reaction forces and release speed

Resultant "active push force" vs. release speed in one individual



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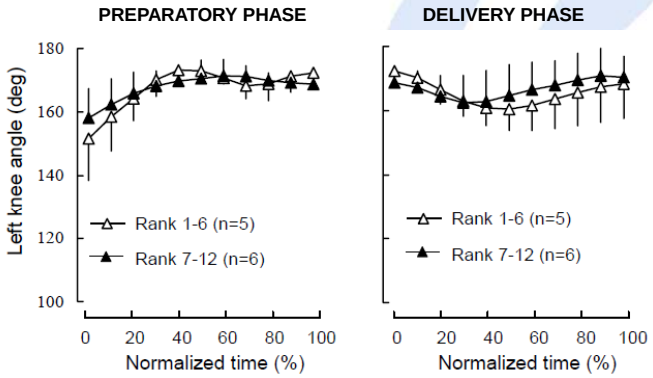
Knee angle of the support leg

Knee angle of the support leg

- Traditionally: The knee angle flexion should be as small as possible during delivery

Knee angle of the support leg

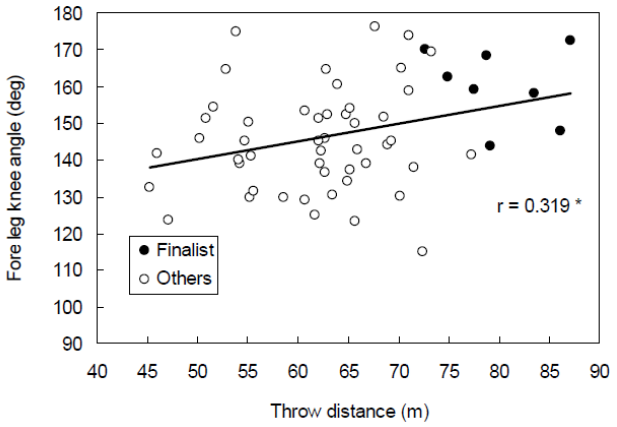
- But, actually there is no connection to throwing result
- Osaka 2007, men:



Tauchi et al 2007

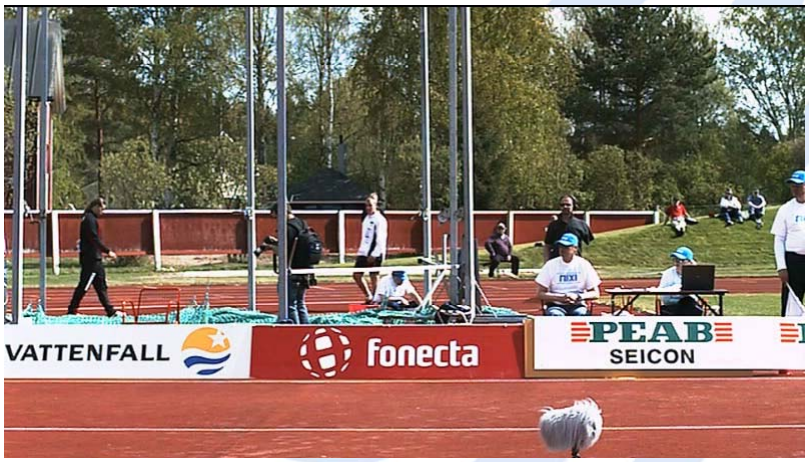
Knee angle of the support leg

- Helsinki 2005 (+ Japanese throwers), men:



Murakami et al 2006

Pull distance and pull time

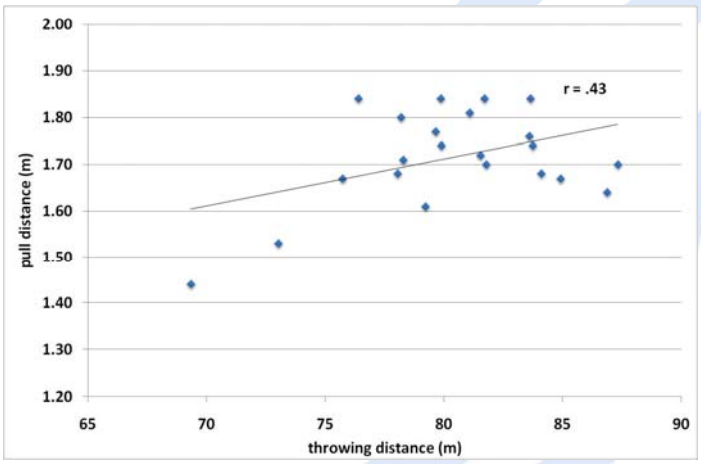


Pull distance

- Very important factor, at least in an early stage of development of young throwers
- Traditionally: longer pull distance –> higher release velocity
- Pull distance vs. throwing distance
  - Helsinki 2005, men r = .43
    Osaka 2007, men no correlation
    KIHU 2008, men r = .43
    KIHU 2008, women r = .46

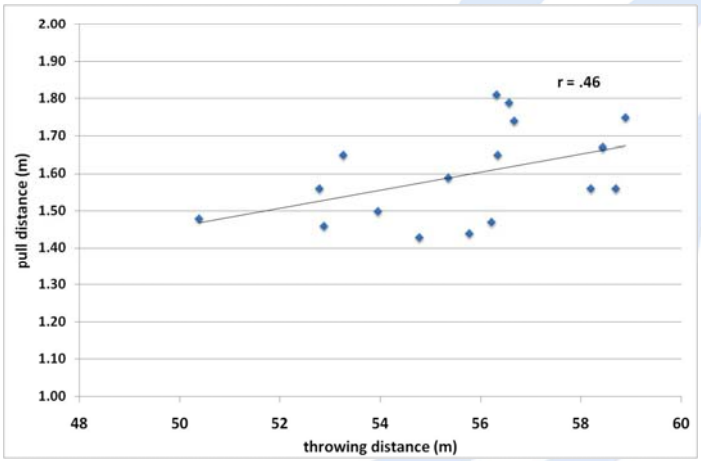
Pull distance vs. throwing distance

Men (KIHU 2008)



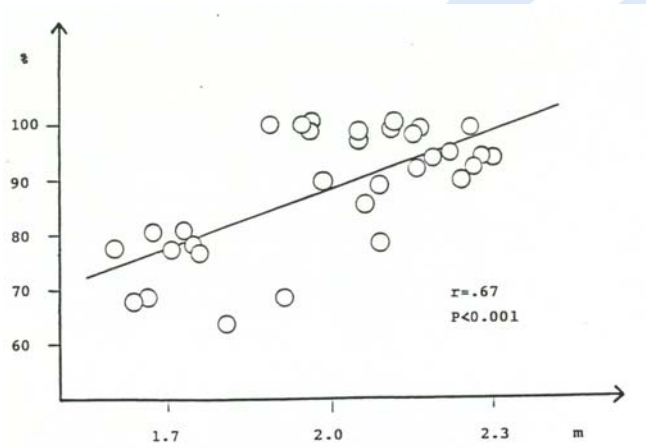
Pull distance vs. throwing distance

Women (KIHU 2008)



Pull distance vs. throwing distance

Pull distance vs. proportional release speed



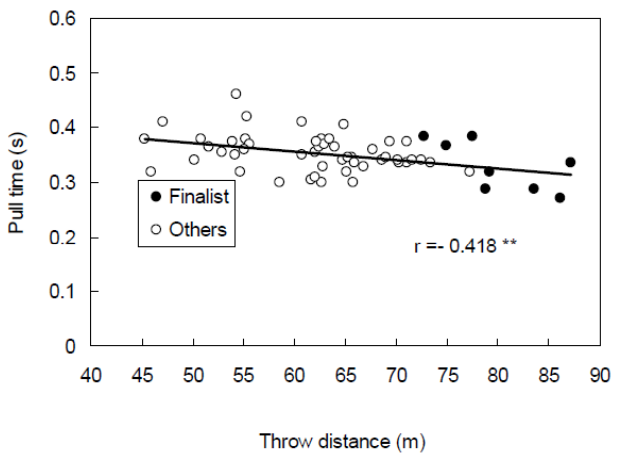
Korjus 1988

Pull time (delivery time)

- Related to pull distance
- Long and fast pull would be the optimal
- Traditionally: better throwers have a shorter pull time
- Pull time vs. throwing distance
  - Helsinki 2005, men — r = -.42
    Osaka 2007, men — no significant correlation
    KIHU 2008, men — no significant correlation
    KIHU 2008, women — no significant correlation

Pull time vs. throwing distance

Helsinki 2005 (+ Japanese throwers):



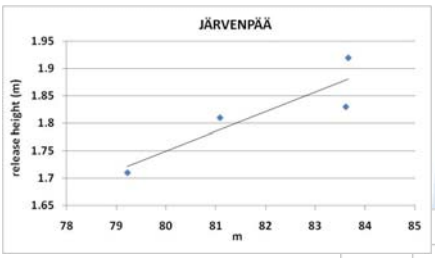
Release height

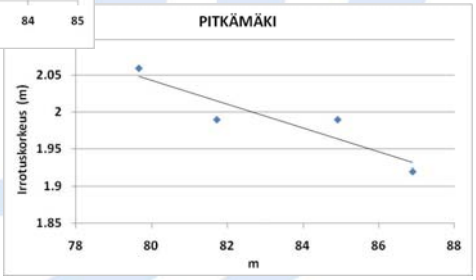
- In basic fysics: the higher release height, the longer distance travelled through the air with same release speed
- Significant factor for example in shot put
- No significant correlations to throwing distance in javelin
- But maybe significant in matter of keeping high posture at the end (e.g. Thorkildsen's posture)

-> maximize pull distance and utilize better the whole body "whip"

Release height – individual differences

- Compare correlations of Pitkämäki and Järvenpää 2008



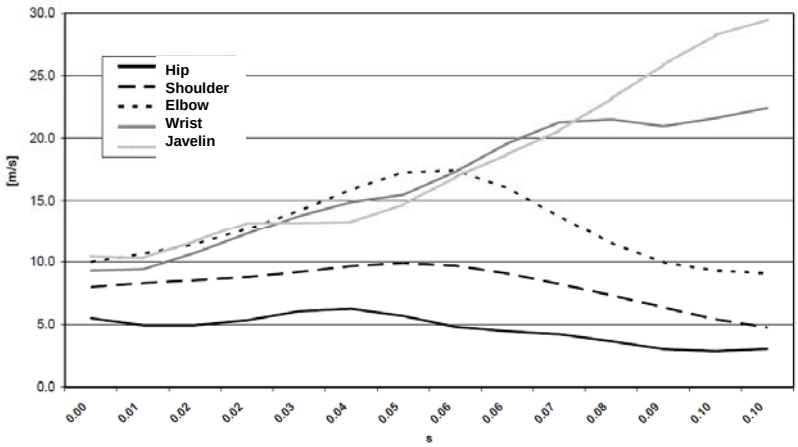


Kinetic chain

- "Whip-action" of the body
- Rotations + linear work to accelerate the javelin
- The highest points in speed of different joints should occur in following order:
  - Hip > shoulder > elbow > wrist > hand > javelin
- It is a matter of timing of muscle work and the way of using support leg

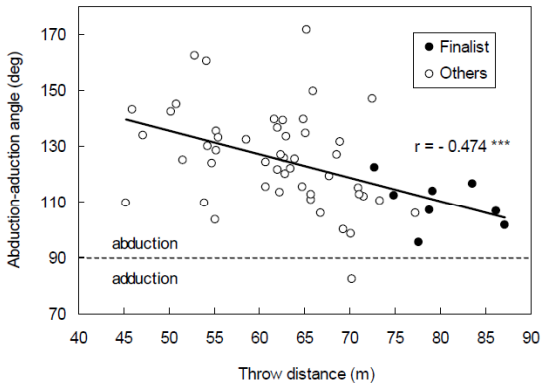
Kinetic chain

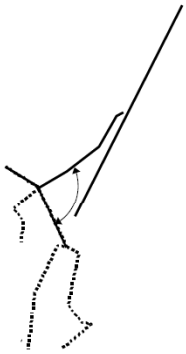
Tero Pitkämäki 2006: 88,17 m
Velocity curves of each joint and javelin



Abduction-adduction angle of shoulder

- Quite surprising connection between abd-add angle of shoulder at release and throwing distance

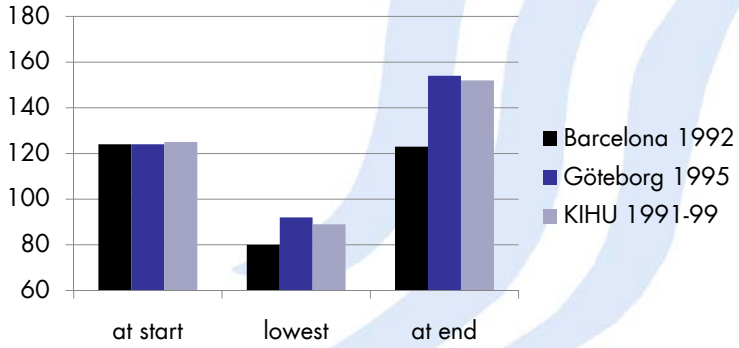




Murakami et al 2006

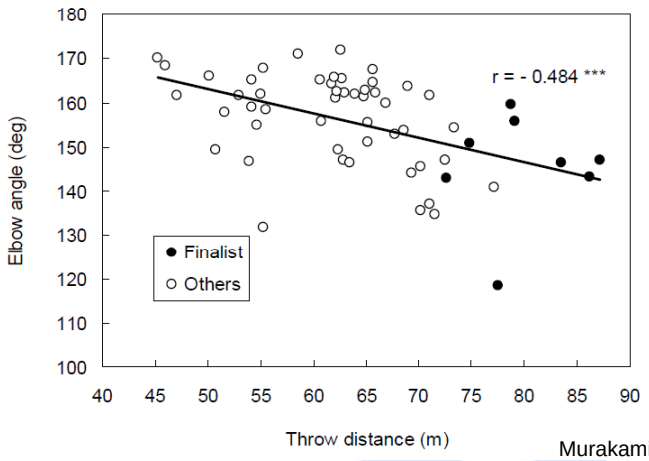
Elbow angle

- Affecting greatly to pull distance
- Traditionally: elbow angle should be around160-180 degrees at final foot contact.
- But, no correlations to supporting that…



Elbow angle at javelin release

Helsinki 2005 (+ Japanese throwers), men:



Murakami et al 2006

Paths of the center of gravity and javelin

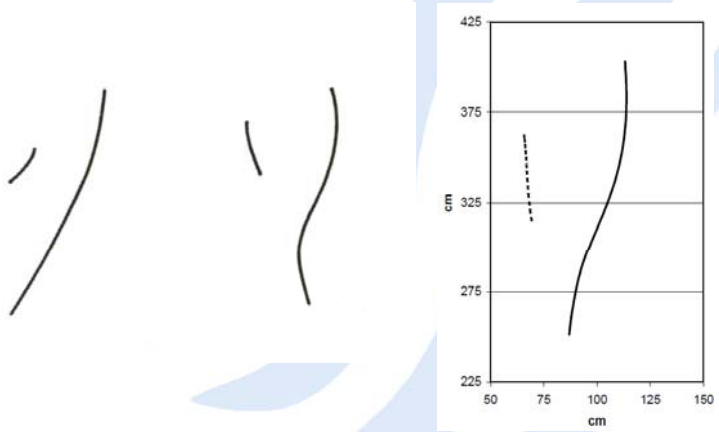
- Sometimes used for describing "paths of forces" in delivery phase
  - Are these paths going to the same direction?
- Difficult to find any optimal combination of the paths

Paths of the center of gravity and grip

Zelezny 1992
88,18 m

Räty 1992
86,60 m

Pitkämäki 2006
88,17 m



Some conclusions

- There are several biomechanical factors affecting to throwing performance and finally to the throwing distance
- It can be proposed that better throwers at high level
  - Have greater approach speed and quicker delivery step
  - Have bigger pull distance
  - Have shorter pull time
  - Have more flexion in the knee joint of the right leg during the preparatory and delivery phase
  - Produce higher ground reaction forces
  - Have smaller abduction-adduction angle of the shoulder at release point

Some conclusions

- But there are also other variables that may be important at individual level!
- And many factors are quite controversial, whether they are connected to the throwing distance or not
- So, an optimal technique is always an individual thing, but should be relaying on well known biomechanical facts
- After all… javelin throwing its very simple:
  - High release velocity AND
  - Good control of the javelin at release

Thank You very many!