EK-1

3RD WORLD JAVELIN CONFERENCE
11–13 November 2014
Kuortane Olympic Training Center

BIOMECHANICS OF JAVELIN THROWING

Frank Lehmann

EUROPEAN ATHLETICS
COACHING SUMMIT SERIES

nordic Sport

OLYMPIC TRAINING CENTER
KUORTANE

Research for Elite Sport

IAT Institute for Applied Training Science

Biomechanics of javelin throwing

Gefördert durch:
Bundesministerium des Innern
aufgrund eines Beschlusses des Deutschen Bundestages
An Institute of the Association IAT/FES e. V.

PD Dr. Frank Lehmann

3rd world javelin conference;
Kuortane 13.11.2014

IAT Institute for Applied Training Science
Research for Elite Sport

Structure of the presentation

1. Preliminary remarks
2. Selected biomechanical aspects of javelin throw
3. Motion technical parameters of javelin throw
4. Motion analysis of the javelin movement at the IAT
5. Selected results of the motion analysis
6. Summary

IAT Institute for Applied Training Science
Research for Elite Sport

1. Preliminary remarks

- About the Institute for Applied Training Science
- About my own person
- Our training scientific support and counselling contains javelin and discus throw; shot put and decathlon/heptathlon; all German top-athletes in this events are involved actually - very close cooperation with their coaches)





IAT Institute for Applied Training Science
Research for Elite Sport

1. Preliminary remarks

- First presentation (today): selected biomechanical aspects of the javelin throw based on our system of movement analysis (special database). This is the initial and final point of our training scientific support and counselling.
- Second presentation (tomorrow): Presentation of our system of training scientific support and counselling, actually used in javelin throw (similar in discus throw and shot put).
- Important question today: What characterizes the top-performances?

IAT Institute for Applied Training Science
Research for Elite Sport

2. Selected biomechanical aspects

According to a physical law

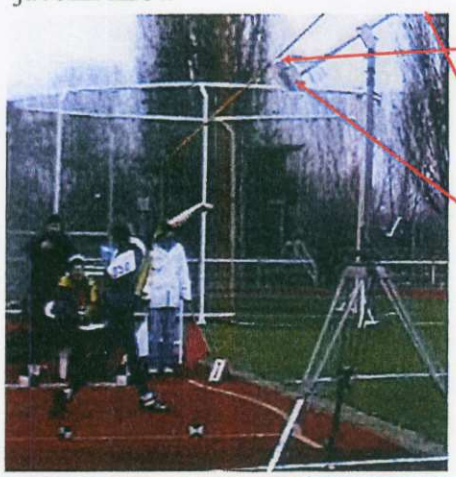
$$D = \frac{v_0^2}{g}\cos\alpha_v\left[\sin\alpha_v + \sqrt{\sin^2\alpha_v + \frac{2h_0 g}{v_0^2}}\right] \pm \Delta L$$

D	throwing distance
v_0	release speed
α_v	angle of release (direction of v_0)
h_0	height of release
g	acceleration of gravity
$\pm\Delta L$	difference in the throwing distance, caused by aerodynamics, air resistance, javelins characteristics etc.)

IAT Institute for Applied Training Science
Research for Elite Sport

2. Selected biomechanical aspects

Several methods of instant measurement of the release speed in javelin throw



Reflector band behind the upper end of the javelin's grip

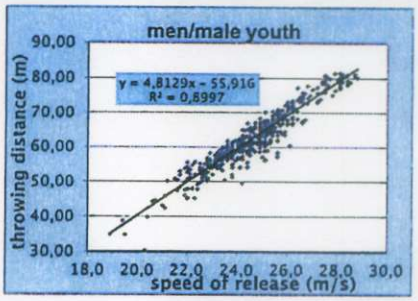
Two LASER light barriers in a distance of 1 meter

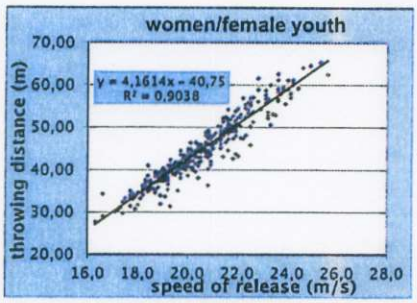
Disadvantage of this method: Two-dimensional measurement

IAT Institute for Applied Training Science
Research for Elite Sport

2. Selected biomechanical aspects

Own results (see figures):
Confirmation of all results getting up today: very close correlation between release speed and throwing distance both in men and women





(📖 Hay, 1978; Terauds, 1985; Hay, 1978; Bartlett, 1988; Hubbard, 1987)

Note: measured by LASER, female; n = 820; male n = 864

IAT Institute for Applied Training Science
Research for Elite Sport

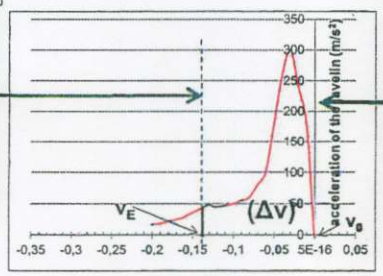
2. Selected biomechanical aspects

Release speed V_0 is the result of the action of force (it equates to the acceleration of the javelin).
That means: The release speed is the integral of the course of the javelin's acceleration over the time during the javelins movement

Release speed v_0 = sum of the velocity of the javelin at the beginning of the main acceleration phase v_E and the increase of velocity during the main acceleration phase Δv (area under the acceleration curve)

Touch down of the left leg

Release



Note: the main acceleration begins before the touch down, but we define the beginning of the main acceleration in this way because of the used measurements

IAT Institute for Applied Training Science
Research for Elite Sport

2. Selected biomechanical aspects

Analysis of top performances - women (later some regards to the used methodology)

	Throwing distance [m]	Javelin's velocity at the touch down of the left leg [m/s]	Increase of velocity during the main acceleration phase [m/s]	Release speed [m/s]	Percentage of the increase of velocity during the main acceleration
Mean/STD > 65,75m (n = 5)	68,62 ± 2,42	8,5 ± 0,4	17,0 ± 0,4	25,5 ± 0,2	66,7 %
Mean/STD 60-65m (n = 15)	61,68 ± 1,60	7,6 ± 0,6	16,5 ± 0,8	24,1 ± 0,8	68,5%
Mean/STD 55-60m (n = 16)	57,80 ± 1,13	7,9 ± 0,71	15,7 ± 0,6	23,6 ± 0,7	66,5%

Differences between the groups 55-60m und 60-65m: higher increase of velocity during the main acceleration exclusively !

The significant differences of the throwing distances and the release speed between the group 60-65m and the group above 65,75m are caused by significant differences of the javelin's velocities at the touch down of the left leg ($p = 0,014$), while no significant differences in the increases of the javelin's velocities during the main acceleration were found ($p = 0.367$)!

IAT Institute for Applied Training Science
Research for Elite Sport

2. Selected biomechanical aspects

Analysis of top performances - men

	Throwing distance [m]	Javelin's velocity at the touch down of the left leg [m/s]	Increase of velocity during the main acceleration phase [m/s]	Release speed [m/s]	Percentage of the increase of velocity during the main acceleration
Mean/STD > 88m (n = 5)	90,76 ± 4,39	9,7 ± 0,2	20,5 ± 1,1	30,2 ± 1,2	67,9%
Mean/STD 81-86,50m (n = 20)	83,17 ± 1,51	9,3 ± 1,1	19,5 ± 1,0	28,8 ± 0,5	66,9%
Mean/STD 76-81m (n = 19)	78,61 ± 1,84	9,4 ± 1,1	18,5 ± 1,1	27,9 ± 0,6	66,9%

Similar to the women: The significant differences between the group 76-81m and 81-86,50m are caused by the increase of the javelin's velocity exclusively !

The significant differences between the groups 81-86,50m und above 88m are caused by significant differences in both velocities (velocity at the beginning and the increase of velocity during the main acceleration)!

IAT Institute for Applied Training Science
Research for Elite Sport

2. Selected biomechanical aspects

It means:

Ca. 1/3 of the release speed is generated by pre-acceleration of the whole system (thrower/javelin) up to the touchdown of the left leg (beginning of the main acceleration phase).

Ca. 2/3 of the release speed are generated by the acceleration of the javelin during the main acceleration phase (touch down of the left leg to release).

There is no continuous development (cross-sectional comparison).

Top performances are characterized by higher velocities of the javelin at the beginning of the main acceleration and higher increases of velocity during the main acceleration (only men).

Very important is the increase of the javelin's velocity up to the touchdown of the left leg in an effective way (not effective: to accelerate only the javelin too early)

IAT Institute for Applied Training Science
Research for Elite Sport

2. Selected biomechanical aspects

Two important aspects in javelin throw:

- To generate a high release speed.
- To transform a high release speed in throwing distance effectively.

We need an extensive **motion analysis**, in order to

- determine the deciding parameters of the release speed and the quality of the release,
- formulate requirements, depending on the throwing distance,
- identify individual reserves at every thrower,
- check the effect of several interventions in the training.

IAT Institute for Applied Training Science
Research for Elite Sport

3. Motion technical parameters

Important movement technique parameters

release speed	quality of release
running-up	angle of release
changeover (running-up → beginning of main acceleration)	angle of attitude
activity of the support leg	difference between the angle of attitude and the angle of release at release (so called uncorrected angle of attack)
delay of throw	angle of yaw
activity of the brace leg	
creation of pre-tension 1 (trunk/ shoulder)	
creation of pre-tension 2 (shoulder/ throwing arm)	
main acceleration of the javelin	

Note: We use special terms in Germany; the delay of throw means: to hold back the throwing arm and shoulder before the main acceleration begins

IAT Institute for Applied Training Science
Research for Elite Sport

4. Motion analysis of the javelin movement at the IAT

The kinematic motion analysis is done both at important competitions and at all diagnostics.

It is executed as an three-dimensional analysis of the video-picture (50 Hz, 50 half frames; both cameras are hardware-synchronized) at every measure. One camera stands at the side (90 degree to the throwing direction), one camera behind the thrower (in throwing direction, at the edge of the javelin throw area- outside)

The results of the motion analysis are integrated in a special database including several figures, videos and picture sequences (MIS „Javelin").

Our database contains actually: Ca. 130 female throwers (680 attempts) und 140 male throwers (740 attempts) with throwing distances from 29,50m to 72,28m (women and female youth) and from 45,50m to 98,48m (men and male youth). It means both current javelin world records are included.

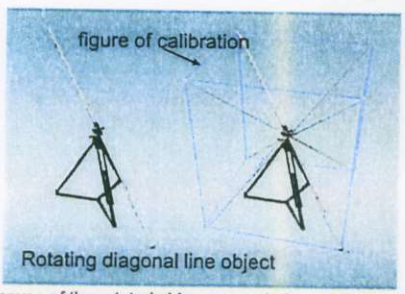
This three-dimensional motion analysis is an important base and part of our work (biomechanical and training scientific support) in Germany.

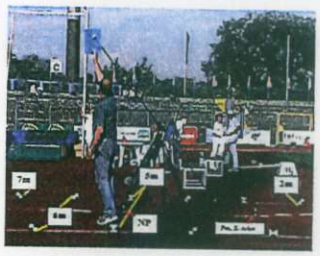
IAT Institute for Applied Training Science
Research for Elite Sport

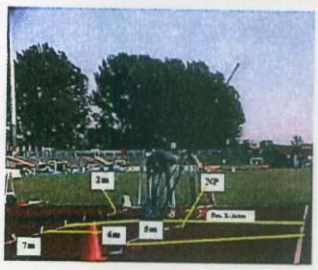
4. Motion analysis of the javelin movement at the IAT

Motion analysis: three-dimensional analysis of the video motion (📖 DRENK, IAT; 2004)

calibration → capture the spacial coordinates







Because of the rotated side camera during recording an additional calibration work is necessary→ every frame we analyzed must be calibrated.

After capturing we must transform the real space coordinates on the javelin throw area (we call it transformation of the zero-point).

IAT Institute for Applied Training Science
Research for Elite Sport

4. Motion analysis of the javelin movement at the IAT

The base of our kinematic analysis is the javelin's movement with seven selected poses:

Take-off of the third last step

Take-off to the cross-over stride

Touch-down after the cross-over stride

0,10s later

Touch-down of the brace leg

0,06s later

Javelin's release

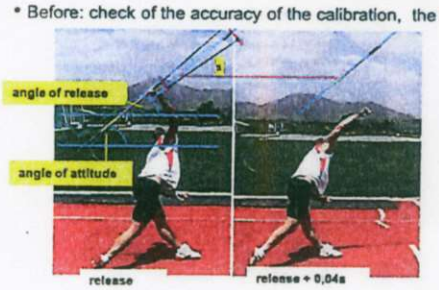
Captured are: all joints (points) and the javelin (end, upper edge of the grip and top) at this poses. grip of the javelin (upper edge), left and right shoulder, left and right hip and the elbow and the wrist of the throwing arm from pose 1 to 0,04s after pose 7

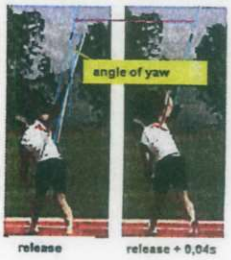
IAT Institute for Applied Training Science
Research for Elite Sport

4. Motion analysis of the javelin movement at the IAT

analysis of the release parameters (to estimate the quality of release)

* Before: check of the accuracy of the calibration, the error of measurement should be smaller than 1%





release speed : Quotient 3D-javelins way s (upper edge of the grip) from the release to the picture 0,04s later and the time (0,04s);

angle of release: angle between the direction of this way and the horizontal plane

angle of attitude: angle between the longitudinal axis of the javelin and the horizontal plane

angle of yaw angle between the direction of the javelin's way and the longitudinal axis of the javelin (yz-plane; rear-view)

IAT Institute for Applied Training Science
Research for Elite Sport

Structure of the database

menu of the database MIS „Javelin"

figure: course of the C.G.-velocities and –ways;

figure: javelins position in the 7 poses (xz- and xy-plane)

figure: course of the angles and angular velocities (hip-, shoulder and upper arm-axis; xy-plane)

Course of the torques

Picture sequence in the 7 poses (side and rear view)

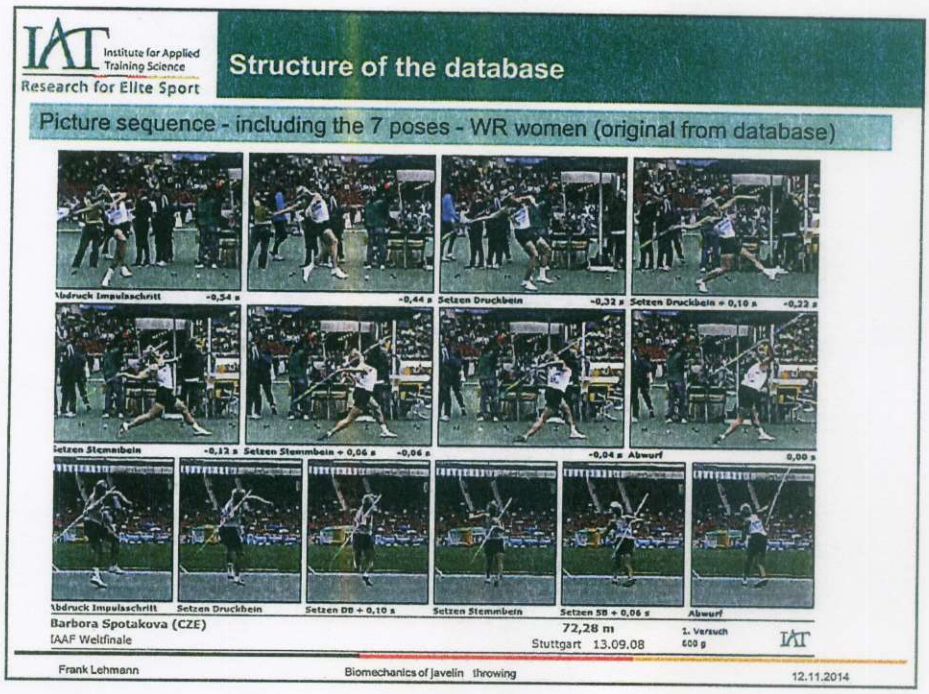
Video side and rear camera (including the possibility of comparison of two movies)

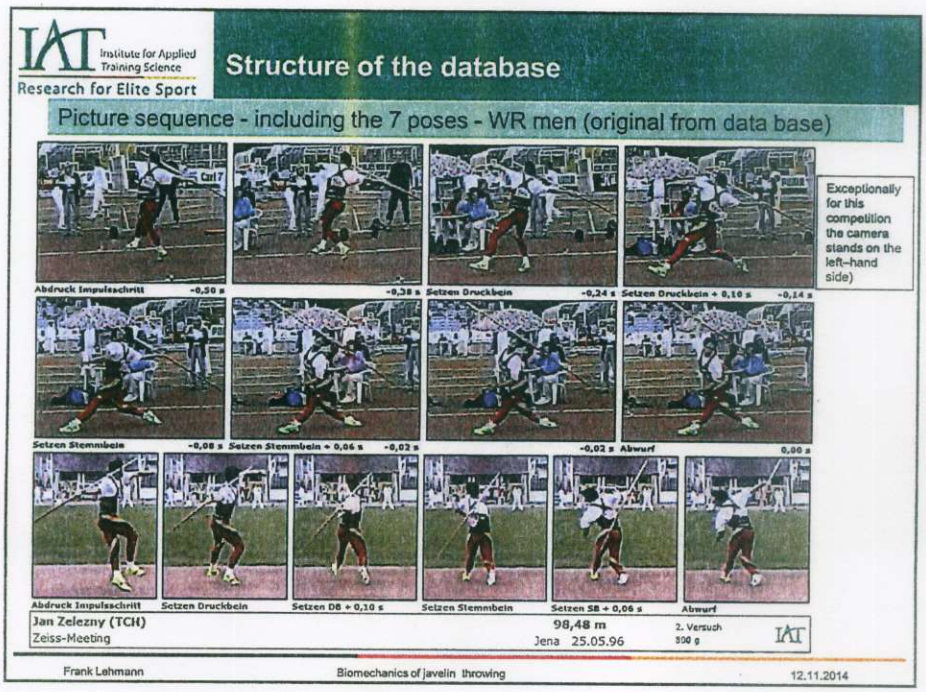
data table

Verbal evaluation of the movement (including hints for the training)

113. Deutsche Meisterschaft 07.07.2013

Sportler	Datum	Weite [m]	Speer [g]	Versuch	Abb. 1	Abb. 2	Abb. 3	Abb. 4	Abb. 5	Abb. 1-5	Abb. 6	Bildreihe	Video	Tabelle	Text
Stahl, Linda	07.07.13	63.70	600	2											
Oberpfeil, Christina	07.07.13	61.73	600	4											
Holzer, Katharina	07.07.13	60.63	600	6											
Rittweg, Mareike	07.07.13	57.18	600	1											
Rosenbauer, Susanne	07.07.13	54.82	600	6											
Schwarz, Desiree	07.07.13	53.60	600	2											
Krebs, Franziska	07.07.13	52.64	600	2											
Eisenlauer, Esther	07.07.13	52.71	600	3											
Stahl, Linda	07.07.13		600	1											


IAT Institute for Applied Training Science
Research for Elite Sport
Structure of the database
Picture sequence - including the 7 poses - WR women (original from database)
Abdruck Impulsschritt -0,54 s
-0,44 s
Setzen Druckbein -0,32 s
Setzen Druckbein + 0,10 s -0,22 s
Setzen Stemmbein -0,12 s
Setzen Stemmbein + 0,06 s -0,06 s
-0,04 s Abwurf 0,00 s
Abdruck Impulsschritt
Setzen Druckbein
Setzen DB + 0,10 s
Setzen Stemmbein
Setzen SB + 0,06 s
Abwurf
Barbora Spotakova (CZE)
IAAF Weltfinale
72,28 m
Stuttgart 13.09.08
1. Versuch
600 g
IAT
Frank Lehmann
Biomechanics of javelin throwing
12.11.2014


IAT Institute for Applied Training Science
Research for Elite Sport
Structure of the database
Picture sequence - including the 7 poses - WR men (original from data base)
Exceptionally for this competition the camera stands on the left-hand side)
Abdruck Impulsschritt -0,50 s
-0,38 s
Setzen Druckbein -0,24 s
Setzen Druckbein + 0,10 s -0,14 s
Setzen Stemmbein -0,08 s
Setzen Stemmbein + 0,06 s -0,02 s
-0,02 s Abwurf 0,00 s
Abdruck Impulsschritt
Setzen Druckbein
Setzen DB + 0,10 s
Setzen Stemmbein
Setzen SB + 0,06 s
Abwurf
Jan Zelezny (TCH)
Zeiss-Meeting
98,48 m
Jena 25.05.96
2. Versuch
800 g
IAT
Frank Lehmann
Biomechanics of javelin throwing
12.11.2014

IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

Methodology

According to our topic (requirements of 70 and 90 meters) some selected results of the motion analysis will presented

Therefore all javelin throwers in our database are separated into three male and three female groups. In the following analysis only the individual longest throws (longest throwing distance) are included.

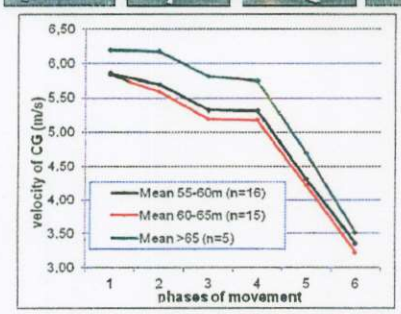
Women:	throwing distance 55-60m (n = 16; mean/STD: 57,80 ± 1,13)
	throwing distance 60-65m (n = 15; mean/STD: 61,68 ± 1,60)
	throwing distance above 65,75m (n = 5; mean/STD: 68,62 ± 2,42)
Men:	throwing distance 75-81m (n = 19; mean/STD: 78,61 ± 1,84)
	throwing distance 81-86,50m (n = 20; mean/STD: 83,17 ± 1,51)
	throwing distance above 88m (n = 5: mean/STD: 90,76 ± 4,39)

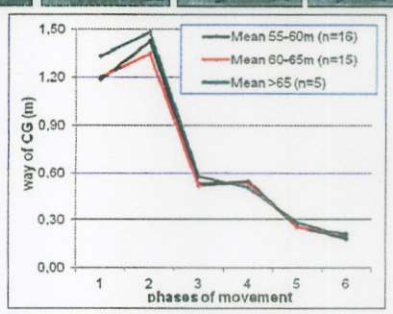
What are the main differences between this groups?

IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

Course of the CG-velocities and -ways – women



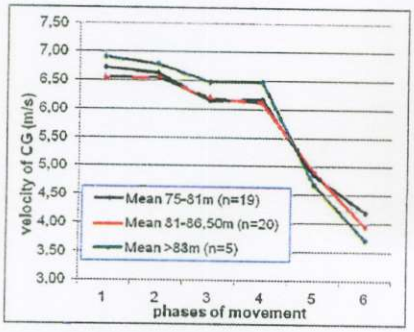


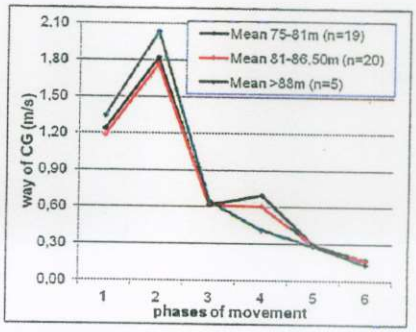
→No differences between 55-60m and 60-65m;
→ Significant higher velocities up to pose 5 (TD brace leg); significant higher velocity-reduction in the braking phase and smaller CG-ways between pose 4 and 5 in the top-athletes (>65,75m)

IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

Course of the CG-velocities and -ways – men



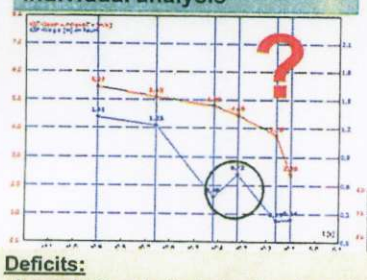


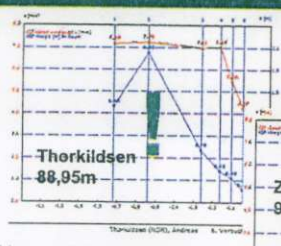
→No differences between 75-81m and 81-86,50m except the way between pose 4 and 5
→Significant higher velocities till pose 5 (TD brace leg); significant higher velocity-reduction in the braking phase and smaller CG-ways between pose 4 and 5 at the top-athletes (>88m)

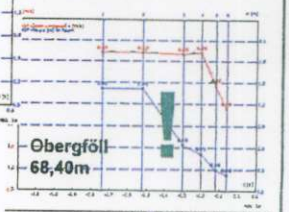
IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

Database - example for an individual analysis







Deficits:
- loss of CG-velocity during impulse stride;
- loss of CG-velocity after touch down support leg during delivery stride
- to small reduction of velocity during braking phase (TD brace leg to release)
- increase of the CG-way in second phase of the delivery stride

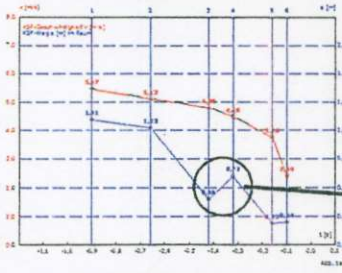
→ Tasks to change in training

IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

Effective activity of the support leg (requirements):

-No loss of CG-velocity after the touch-down of the support leg;
-No loss of CG-velocity in the second half of the delivery stride (effective pressure from the right foot);
-Pressure from the right foot to the right hip (hit the hip) without knee-extension (right knee must go to the ground);
-If the knee is extended→ the pressure goes to the whole body (including the upper body and the throwing arm) and the CG-way increases;
-Therefore: accelerate only the lower part of the body and delay the movement of the upper body relatively



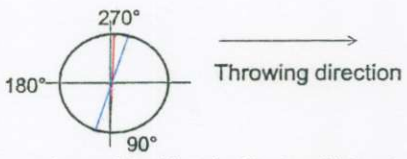
These are the requirements and we must find out the individual solutions to turn it into the movement

IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

Comparison of selected parameters – activity of support leg

	Women			Men		
	Time of delivery stride (ms)	Angle of the hip axis at the TD BL [°]	Maximum of hip velocity [m/s]	Time of delivery stride (ms)	Angle of hip axis at TD BL [°]	Maximum of hip velocity [m/s]
Mean/STD 55-60m/75-81m	204± 31	109 ± 9	5,82± 0,4	213 ± 36	112 ± 8	6,81 ± 0,5
Mean/STD 60-65m/81-86,50m	204± 24	106± 12	5,72± 0,3	200 ± 27	110± 11	6,73 ± 0,5
Mean/STD >65m/> 86m	188± 11	101± 11	6,24± 0,4	164 ± 9	94 ± 14	7,26 ± 0,2



xy-plane; red line: hip-axis of the top-athletes at the touch-down of the brace leg (blue line: 81-86,50m)

Besides the differences in the CG-ways there are significant smaller angles of the hip-axis, shorter times of the duration of the delivery stride and higher hip-velocities at the top-athletes (men and women) as the result of an effective activity of the support leg

IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

Activity of the brace leg

pose 5 | pose 5 | pose 6

	reduction of CG-velocity [m/s] 5→ 6	angle of the brace leg at touch-down [°]	knee-angle of the brace leg at TD [°]	knee-angle 0,06s after TD [°]
Mean/STD 55-60m	-1,01 ± 0,21	44 ± 3	164± 4	148 ± 12
Mean/STD 60-65m	-0,96 ± 0,27	45 ± 4	166 ± 5	150 ± 8
Mean/STD >65m	-1,06 ± 0,31	41 ± 2	164 ± 3	147 ± 7

Frank Lehmann | Biomechanics of javelin throwing | 12.11.2014

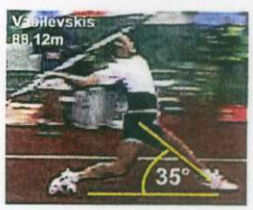
IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

Activity of the brace leg

	reduction of CG-velocity [m/s] 5→ 6	angle of the brace leg at touch-down [°]	knee-angle of the brace leg at the TD [°]	knee-angle 0,06s after TD [°]
Mean/STD 75-81m	-1,32 ± 0,49	46 ± 4	167 ± 6	148 ± 13
Mean/STD 81-86,5m	-1,21 ± 0,32	44 ± 3	169 ± 5	148 ± 9
Mean/STD >88m	-1,79 ± 0,54	41 ± 4	171 ± 5	155 ± 15

As a result of the larger activity of the support leg (including the delay of the upper-body forward movement):
The touch-down of the brace leg is more flat and leads to a higher reduction of CG-velocity in the first part of the main acceleration

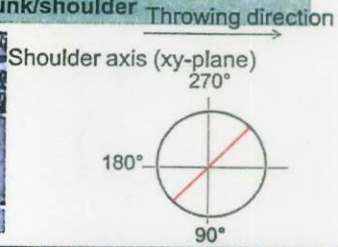


Frank Lehmann | Biomechanics of javelin throwing | 12.11.2014

IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

Delay of the throw:
→To enlarge the way of the javelin in the main acceleration;
→ To increase the pre-tension in the part of trunk/shoulder



	Release speed [m/s]	Shoulder axis TD bl [°]	Elbow angle TD bl [°]	Javelin's velocity TD bl [m/s]	Javelin's velocity TD bl (%) *
Mean/STD 55-60m	23,6 ± 0,7	139 ± 14	117 ± 10	7,88±0,49	33,4
Mean/STD 60-65m	24,1 ± 0,8	138 ± 11	123 ± 15	7,57±0,63	31,4
Mean/STD >65,75m	25,5 ± 0,2	138 ± 14	116 ± 9	8,55±0,35	33,5

* In relation to the release speed

IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

Delay of the throw

	Release speed [m/s]	Shoulder axis TD bl [°]	Elbow angle TD bl [°]	Javelin's velocity TD bl [m/s]	Javelin's velocity TD bl (%) *
Mean/STD 75-81m	27,9 ± 0,6	139 ± 15	116 ± 11	9,36±1,13	33,5
Mean/STD 81-86,5m	28,8 ± 0,5	142 ± 12	117 ± 8	9,34±1,03	32,4
Mean/STD >88m	30,2 ± 1,2	135 ± 4	116 ± 8	9,74±0,24	32,2

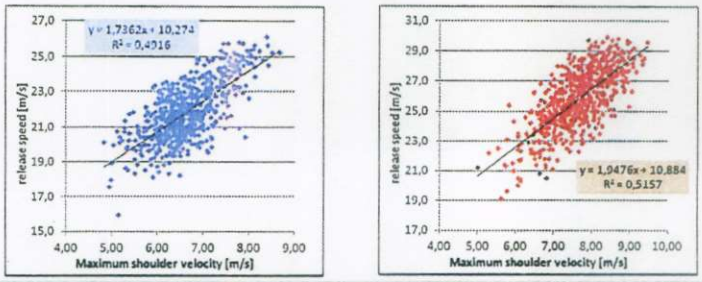
No significant differences in the delay of the throw means
→The same (partly shorter) ways of the javelin lead to higher increases of velocity in the top-athletes (reason: higher maximum acceleration of the javelin during the main acceleration phase)
→ More pre-tension in the trunk/shoulder as a result of the higher activity of the support leg (right hip is moved more forward)

IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

The maximum of the shoulder velocity as a result of the higher pre-tension

There is a very high correlation between the maximum of the shoulder velocity and the release speed at the women/female youth (left, n = 635) and at the men/male youth (right; n = 676)



It means: The maximum of the shoulder velocity (as a result of a higher pre-tension of the trunk/shoulder of the body) is the most important parameter to improve the release speed. Similar to: If you want to use the whiplash effect you must accelerate (and brake after this) the handle of the whip at first. If the throwing arm is sufficiently delayed you can produce a high velocity at the end of the whip.

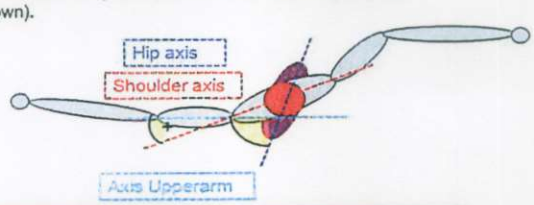
IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

Generate pre-tension trunk/shoulder

A higher pre-tension in the trunk/shoulder part of the thrower is generated after an effective activity of the support leg, a large amount of reduced speed after the touch down of the brace leg and a good delay of the throw (as shown).

This appears as an high torque between hip-axis and shoulder axis.



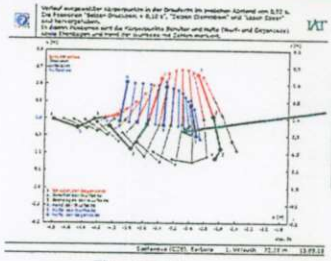
women	difference hip/shoulder-axis [°]	men	difference hip/shoulder-axis [°]
Mean/STD 55-60m	30 ± 9	Mean/STD 75-81m	26 ± 17
Mean/STD 60-65m	32 ± 14	Mean/STD 81-86,5m	29 ± 16
Mean/STD >65m	37 ± 11	Mean/STD >88m	41 ± 13

Top-athletes have a significant higher torque between hip and shoulder axis at the touch down of the brace leg.

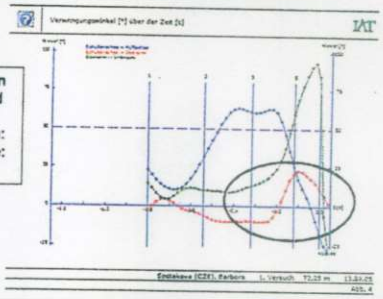
IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

The pre-tension in the part shoulder/upper arm is generated after the acceleration of the throwing shoulder (and a relatively delayed throwing arm). Because of the velocity of the movement we must consider the course of the torques.



Top-view



Torque between upper arm and shoulder (red: shoulder; green: upper arm; blue: hip axis)

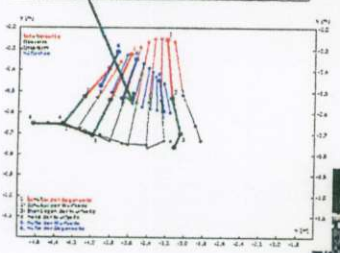
The torque between shoulder axis and upper arm (screwed) increases (red line) during dissolving the torque between hip and shoulder axis (blue line in the right figure). This is a sign for a good whiplash effect.

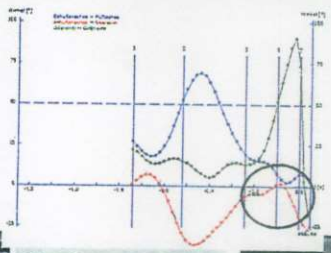
IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

Example for a non sufficient pre-tension in the part of shoulder/upper arm (database)

Top view (no torque between shoulder and upper arm)





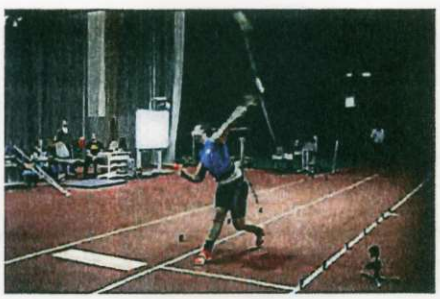
Nearly no torque between shoulder axis and upper arm

(Shoulder and upper arm are moved forward simultaneously)

IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

The acceleration of the javelin during the main acceleration phase can not be measured exactly by the motion analysis (50 Hz).
We use the so called „Tenso-javelin" at the diagnostics and in the training camps (not in competition).
→ Second presentation



IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

Quality of release

	angle of release [°]	angle of attitude [°]	angle of yaw [°]	angle of attack ar/aa [°]	angle of attitude at the TD bl [°]
Mean/STD 55-60m	34,5 ± 3,9	41,5 ± 4,6	13,7 ± 4,6	7,0 ± 6,3	39,7 ± 6,4
Mean/STD 60-65m	34,8 ± 2,1	39,3 ± 3,7	9,0 ± 4,3	4,5 ± 3,0	37,5 ± 4,5
Mean/STD >65,75m	35,7 ± 2,3	40,1 ± 3,7	8,7 ± 3,1	4,4 ± 4,1	38,2 ± 3,1

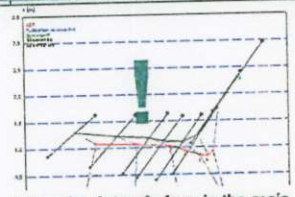
	angle of release [°]	angle of attitude [°]	angle of yaw [°]	angle of attack ar/aa [°]	angle of attitude at the TD bl [°]
Mean/STD 75-81m	33,6 ± 2,8	37,1 ± 2,3	9,9 ± 4,1	3,5 ± 2,5	35,8±2,5
Mean/STD 81-86,5m	34,0 ± 2,7	36,9 ± 3,6	10,1 ± 3,9	2,9 ± 3,3	35,4±4,5
Mean/STD >88m	35,4 ± 2,8	36,6 ± 4,2	8,5 ± 1,9	1,2 ± 2,2	34,3±3,5

There are no significant differences in the quality of release between the groups (exception: women 55-60m);
Tendency: top-athletes have higher angles of release, smaller angles of attack and smaller angles of yaw;

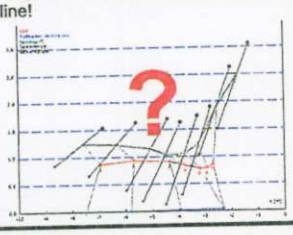
IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

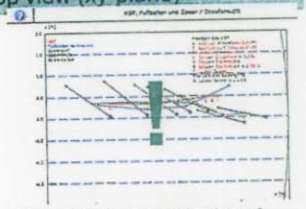
Quality of release
Lateral view (xz-plane)



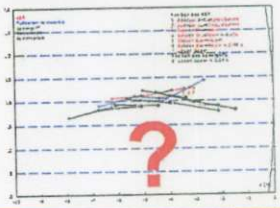
Objective lateral view: in the main acceleration (up to release + 0,04s) the longitudinal axis of the javelin should be one line!



Quality of release
Top view (xy-plane)



Objective top view: after the lateral backward-movement (men more than women) the javelin should be lead into the throwing direction.

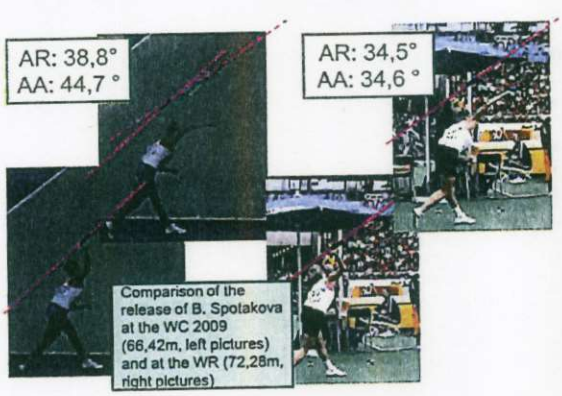


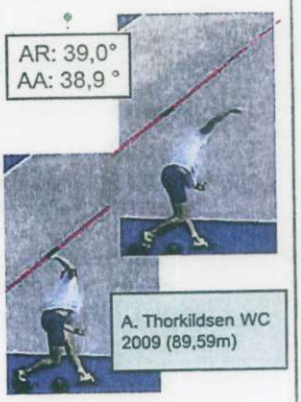
Frank Lehmann — Biomechanics of javelin throwing — 12.11.2014

IAT Institute for Applied Training Science
Research for Elite Sport

5. Selected results of the motion analysis

angle of release (AR) and angle of attitude (AA) at top athletes





WR J. Zelezny: AR: 34,8° AA 35,4° AY: 7,1°

Frank Lehmann — Biomechanics of javelin throwing — 12.11.2014

IAT Institute for Applied Training Science
Research for Elite Sport

6. Summary

Top-Performances are characterized by:

-Higher CG-velocities up to the touch-down of the brace leg (without or nearly without loss);

-Bigger effect of the brace leg (higher amount of reduced CG-velocity by more flat touch down of the brace leg);

-More forward movement of the right hip (base: more activity in the support leg) leads at the same delay of throw to a higher pre-tension in the trunk/shoulder part of the body;

-This is important for the higher shoulder velocity (the parameter most influencing the release speed).

-In tendency: higher angles of release, smaller angles of attack (< 3 degree) and smaller angles of yaw (< 10 degree).

IAT Institute for Applied Training Science
Research for Elite Sport

6. Summary

The movement analysis at competitions and diagnostics (inclusive the evaluation and the hints for the training) play an important role in our training scientific support and counselling.

According to the physical abilities (besides others) are very important:

- reactive und velocity-abilities of the legs;
- to ensure an individual optimal relation between strength/tension and flexibility in the trunk- and shoulder muscles.

There are a lot of ways to throw 60m (women) or 80m (men). But there are not so many ways to reach absolute top-performances.


Research for Elite Sport
IAT Institute for Applied Training Science
Many thanks for
your kindly attention!
Institut für Angewandte Trainingswissenschaft
Marschnerstraße 29, 04109 Leipzig
PD Dr. Frank Lehmann
FG-Leiter Wurf/Stoß
E-Mail: flehmann@iat.uni-leipzig.de
Tel.: + 49 341 4945 - 188
Fax: + 49 341 4945 - 400
Gefördert durch:
Bundesministerium des Innern
aufgrund eines Beschlusses des Deutschen Bundestages
An Institute of the Association IAT/FES e. V.