EK-4

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

BIOMECHANICAL ASSISTANCE TO THE TRAINING PROCES IN GERMANY

Frank Lehmann

EUROPEAN ATHLETICS
COACHING SUMMIT SERIES

Nordic Sport

OLYMPIC TRAINING CENTER
KUORTANE

Research for Elite Sport

IAT Institute for Applied Training Science

Biomechanical support and counselling to the training process in Germany

Gefördert durch:
Bundesministerium des Innern
aufgrund eines Beschlusses des Deutschen Bundestages

An Institute of the Association IAT/IFES e. V.

PD Dr. Frank Lehmann
FG-Leiter Wurf/Stoß

3rd world javelin conference;
Kuortane 13.11.2014

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Structure of the presentation

1. Preliminary remarks
2. Actual situation in the throwing events in Germany
3. Parts of the training scientific-support and counselling
   - 3.1. Analysis of the competition movement
   - 3.2. Diagnostics of the physical abilities
   - 3.3. Training with measurement systems
   - 3.4. Training scientific support in main training camps
4. Actual deficits and problems
5. Summary and conclusions

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1. Preliminary remarks

The philosophy of our institute:

- To support the German athletes, in order to be successful at the international main competitions (especially Olympic Games and world championships)
- Therefore not only biomechanical assistance, but support and counselling in the whole training process (training scientific support)

Besides Finland as the country with the greatest tradition in javelin throw, also Germany has a long and successful period in the throws in general, especially in the javelin throw

Long tradition of the scientific support and counselling (former FKS in Leipzig)

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2. Actual situation in the throwing events in Germany - javelin

Since the European Championships 2002 German female and/or male javelin throwers won a medal at every international main competition: Olympic Games, World and European Championships

Actually we have a different situation:

- Only **4 women** in the long-term preparation for the 2016 Olympic Games - but they were and are very successful (C. Obergföll; L. Stahl; K. Molitor; C. Hussong):
- **8-10 men** in the long-term preparation for the 2016 Olympic Games - but most of them had and have a lot of injuries every year: Besides T. Röhler (DL-winner 2014), A. Hofmann (winner of the 2014 Team-Cup) in this year 6 from this 10 were not able to start the competition season (M. de Zordo - World Champion 2011, T. Wöschler - European U23 Champion 2011, B. Seifert - Second place at European U23 2013, T. Häber - 8. of the 2012 OG, J. Weber, European U20 Champion 2013, L. Hamann - Germanys best javelin thrower in 2013)

The following system of support we first of all use at all athletes having the objective to take part at an international championship (adults and U20)

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3. Parts of the training scientific support

Motion analysis in competitions
(check of the technique and the structure of the competition movement (comparison to the ideal-typical technique model)

Training scientific support in training camps

Diagnostics
(check of the level of important physical abilities; comparison to the profile of requirements

Training with measurement systems
(increase of the implementation of the abilities into the javelin movement; decrease of individual deficits)

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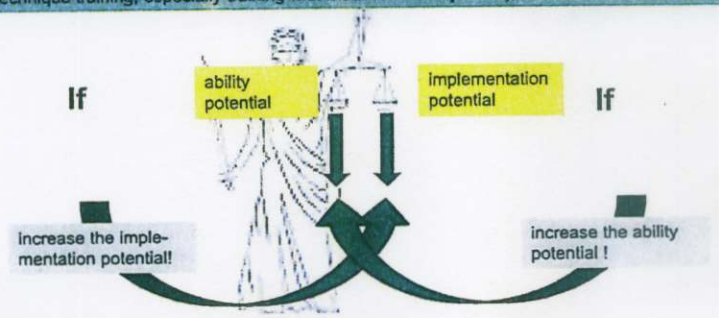
3. Parts of the training scientific support

Important question: Are deficits caused by a bad movement execution or by insufficient abilities?

1 **ability potential** (check/change of important abilities)

2 **implementation potential** (check/change of important movement parameters by using technique training, especially training with measurement systems);



General objective: to ensure a steady-state between both

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Training scientific support in the course of a year

Time	Main contents
November	team week/check of the physical abilities
January	team week/diagnostics (physical abilities and analysis of the javelin movement)
February	training with measurement systems (evaluation of deficits, calculated at the diagnostics in January; discussion of possibilities for changes in training; using this possibilities in the javelin movement; result: hints for the next training period
February/ March	training camp; implementation of the training hints in order to change the movement at low running-up speed; training of the physical abilities according to the evaluation of the diagnostics (January)
End of March	training with measurement systems (check of the implementation of the changes into the movement; further hints for the next training period for each thrower)
April	training camp; implementation of the training hints in order to change the movement at higher running-up speed; influence of the quality of release
Beginning of May	training with measurement systems to check the progress; last diagnostics of the physical abilities before the competition period starts;
End of May	motion analysis at the competition-feedback; hints for the training
June	motion analysis at the competition-feedback; hints for the training
July	motion analysis at the competition-feedback; hints for the training in preparation of the peak
	Only by individual need: training with measurement systems

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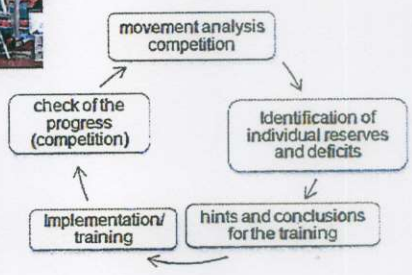
3.1. Analysis of the competition movement

Confirmation or clarification of movement-technical requirements



dominant function in the loop (initial and final point of interventions in the training)



database „MIS Javelin“ as important instrument

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3.2. Diagnostics of the physical abilities

General physical abilities:

- speed strength/jumping strength of the legs **(5 run long jumps)**
- speed locomotion of lower extremities **(30m flying sprint);**
- maximum force/speed strength of the whole body-extensors chain **(snatch)**;
- specific explosive power/throwing strength **(front and back throw test)**;

On the basis of many data we can formulate physical requirements.

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3.2. Diagnostics of the physical abilities

Physical requirements in javelin throw (women)

Throwing distance	Front throw test (4kg)	Back throw test (4kg)	30m flying sprint	5 run long-jumps (app. 5m inrun)	Snatch (1RM)
68,00m	15,37m	17,48m	3,35s	17,70m	81,0kg
67,00m	15,23m	17,33m	3,36s	17,56m	79,5kg
66,00m	15,09m	17,18m	3,38s	17,41m	78,0kg
65,00m	14,94m	17,02m	3,40s	17,26m	76,0kg
64,00m	14,80m	16,87m	3,41s	17,12m	74,5kg
63,00m	14,65m	16,72m	3,43s	16,97m	73,0kg
62,00m	14,50m	16,56m	3,44s	16,82m	71,0kg
61,00m	14,36m	16,41m	3,45s	16,68m	69,5kg
60,00m	14,22m	16,25m	3,47s	16,53m	68,0kg
59,00m	14,07m	16,09m	3,48s	16,38m	66,0kg
58,00m	13,93m	15,94m	3,50s	16,23m	64,5kg
57,00m	13,78m	15,79m	3,51s	16,08m	63,0kg
56,00m	13,64m	15,63m	3,52s	15,94m	61,0kg
55,00m	13,49m	15,48m	3,54s	15,79m	59,5kg
54,00m	13,35m	15,33m	3,55s	15,65m	58,0kg
53,00m	13,20m	15,17m	3,57s	15,50m	56,5kg
52,00m	13,05m	15,01m	3,58s	15,35m	54,5kg
51,00m	12,91m	14,86m	3,60s	15,21m	53,0kg
50,00m	12,76m	14,61m	3,61s	15,06m	51,5kg
49,00m	12,62m	14,55m	3,62s	14,91m	49,5kg
48,00m	12,47m	14,40m	3,64s	14,76m	48,0kg
47,00m	12,33m	14,25m	3,65s	14,61m	46,5kg
46,00m	12,18m	14,09m	3,67s	14,47m	44,5kg

Frank Lehmann Support and counselling in the training process in Germany 13.11.2014

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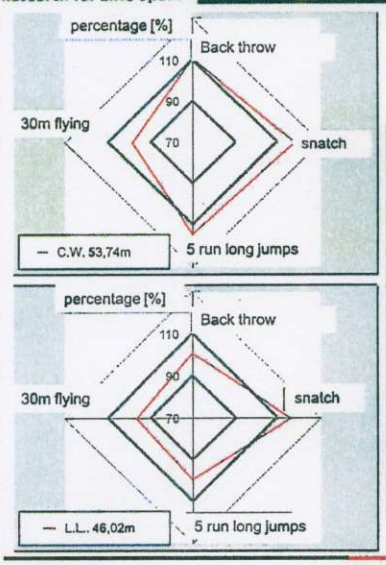
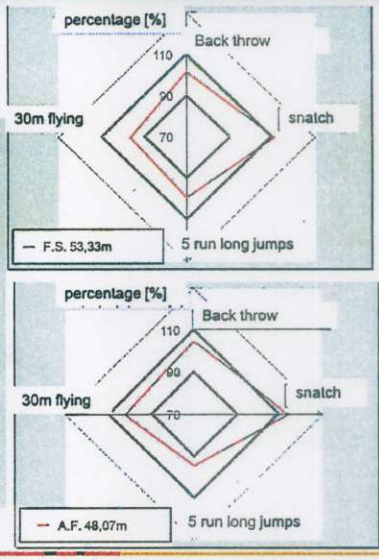
3.2. Diagnostics of the physical abilities





Percentage of the physical abilities of selected German female throwers (juniors; according to the physical require-ments)

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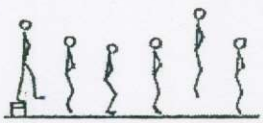
3.2. Diagnostics of the physical abilities

Drop jumps, to check the reactive abilities (SSC) - these are important physical abilities for top-performances (to minimize the loss of CG-velocity up to the touch down of the brace leg)



Combination of eccentric and concentric muscle activity (for example important in the contact phase of the support leg after the cross-over stride)

The concentric work must be equal or larger than the eccentric work (in opposite to the take-off in the long-jump).

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3.2. Diagnostics of the physical abilities

Results - Reactive abilities (drop jumps)

Means and STD in comparison between male and female throwers in javelin throw, discus throw and shot put (Index: relation between concentric and eccentric work)

event (female/ male)	women (n=86)				men (n=94)			
	24cm falling height		44cm falling height		24cm falling height		44cm falling height	
	Contact time [ms]	Index	Contact-time [ms]	Index	Contact-time [ms	Index	Contact-time [ms	Index
shot put (n=26/25)	190±25	1,23±0,14	195±28	0,85±0,12	187±25	1,23±0,14	192±19	0,90±0,11
discus throw (n=27/36)	183±23	1,18±0,17	195±24	0,86±0,11	180±14	1,34±0,15	195±28	0,97±0,10
javelin throw (n=26/33)	174±19	1,34±0,18	180±23	0,95±0,13	176±16	1,34±0,15	184±15	0,98±0,10
heptathlon (n=7)	179±7	1,26±0,11	180±5	0,90±0,09				
Mean/STD of all (n=86/94)	183±22	1,24±0,17	190±25	0,88±0,12	181±18	1,30±0,15	190±0,22	0,95±0,11

requirements:
discus throw/shot put: at 24cm falling height: Index > 1,0 und contact time < 200ms;
javelin throw: at 44cm falling height Index > 1,0 und contact time < 200ms;

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3.2. Diagnostics of the physical abilities

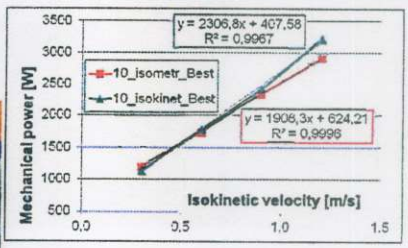
Maximum strength of the lower extremities (isometric and isokinetic maximum force) at the IsoMed 2000

Knee-extension in sitting position at the IsoMed 2000; isometric and then isokinetic at four several velocities.

results:
- Maximum force at the isometric and isokinetic knee extension;
- Maximum force/body weight;
- Laterality (left and right leg are separately measured);
- Mechanical power (product: strength and velocity).

Increase of the mechanical power in the several velocity steps are very important

Comparison of the 10 isometric best with the 10 isokinetic best throwers



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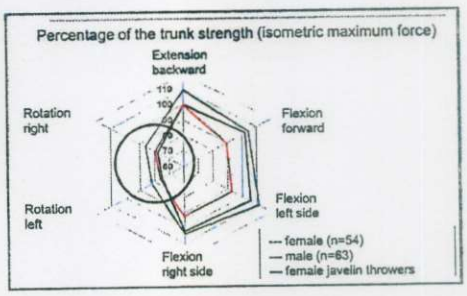
3.2. Diagnostics of the physical abilities

Diagnostics of the strength of the trunk muscles (six several movements in three axes at the „PEGASUS" (special strength machine)*
results: Percentage to the requirements in average (figure above) and at selected throwers (figure below)



Found at the most throwers: strength deficits of the rotational trunk muscles

* in cooperation with M. Witt, University of Leipzig

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3.2.diagnostics of the physical abilities

Partial confirmation:

"...The results were as follows: PTR (peak of strength trunk rotation right) was closely related to the JP (throwing distance: 48.17±3.21m; n=10; female) in right side rotation (30deg/sec: r = 0.624, 60deg/sec: r = 0.709, 120deg/sec: r = 0.732, 180deg/sec: r = 0.844, 240deg/sec: r = 0.779). Similarly: PTL and JP in left side rotation (30deg/sec: r = 0.729, 60deg/sec: r = 0.787, 120deg/sec: r = 0.786, 180deg/sec: r = 0.887, 240deg/sec: r = 0.762).

(🕮 Aoyama, S; Aoyama,T.; Tsunodat, N. (Kokushikan university , Japan); 12th Annual Congress of the ECSS, 11–14 July 2007, Jyväskylä, Finland)

What can we do to increase the strength of the rotational muscles of the trunk ?

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3.2. Diagnostics of the physical abilities

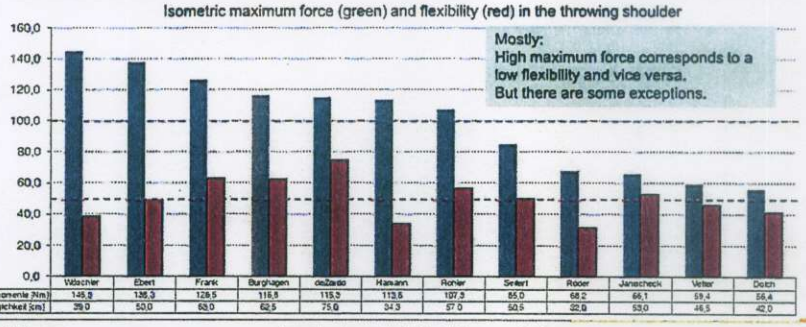
Diagnostics of the relation between

Muscle tension
(isometric strength maximum)

flexibility

Shoulder joint

Isometric maximum force (green) and flexibility (red) in the throwing shoulder



Mostly:
High maximum force corresponds to a low flexibility and vice versa.
But there are some exceptions.

	Wöchler	Ebert	Frank	Burghagen	deZeeuw	Hamann	Rohler	Seifert	Roder	Janecheck	Vetter	Dolch
Drehmomente [Nm]	145,9	136,3	128,5	118,5	118,3	113,6	107,3	85,0	68,2	66,1	59,4	56,4
Beweglichkeit [cm]	29,0	50,0	58,0	62,5	75,0	34,3	57,0	50,5	32,0	53,0	46,5	42,0

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3.2. Diagnostics of the physical abilities

Our throwers partly have deficits in the coordinative skills:

- in the ability to throw with a good quality of the release parameters (AR = AA),
- to vary the angle of release,
- to vary the angle of attitude,
- to throw the javelin forward, to the left side, to the right side,
- to throw the javelin at different wind conditions effectively,
- to perform a good work of the brace leg at wet conditions or at a very soft or hard track,
- to vary the running-up speed effectively.

Very impressive: throw of a match over 30 meters (Hohn); different throws at the warming up before competition Zelezny (HWT 2003); Makarow (Anhalt 2004); correction of the angle of release by Thorkildsen (WC 2009)

How can we improve this abilities by training?

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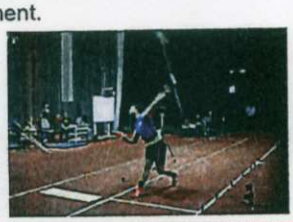
3.3. Training with measurement systems

The training with measurement systems is a central part of our support.

The objectives are first of all,

1. to bring important parameters of the individual movement closer to the ideal-typical technique model,
2. to check and to increase the implementation of the physical abilities into the javelin movement,
3. to train coordinative abilities in order to vary the parameters of the javelin's movement.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3.3. Training with measurement systems

On the basis of the competition movement analysis we

- identify motion-technical deficits (target actual comparison),
- illustrate this deficits based on several biomechanical parameters and courses,
- set the main points of the training intervention (in close cooperation with the coach), taking into account the individual accouterment (actual level of the abilities) of the thrower,
- prove exercise and possibilities to eliminate the deficits.

- The objective is the ideal-typical technique model.
- Duration and scope of the intervention depend on the type of motion correction.

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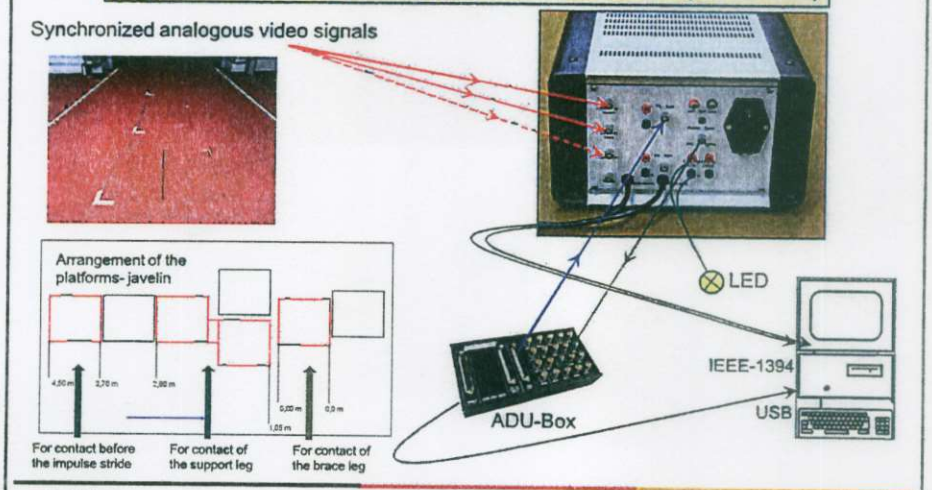
3.3. Training with measurement systems

measuring systems: coupling of several measurement platforms, two video cameras and a acceleration sensor (all units are synchronized)



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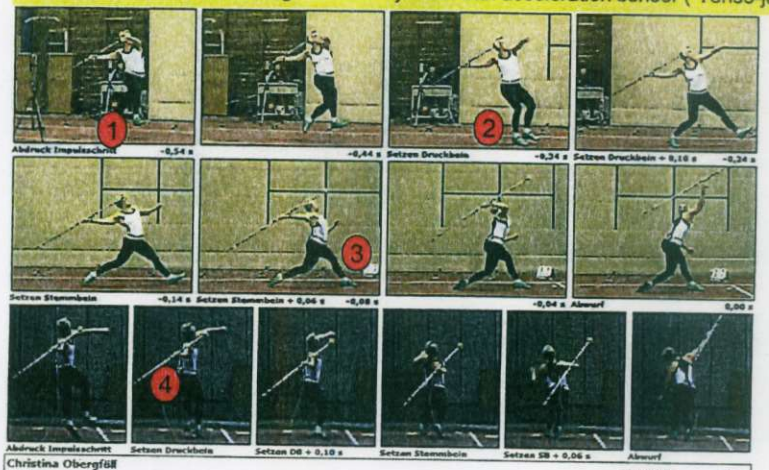
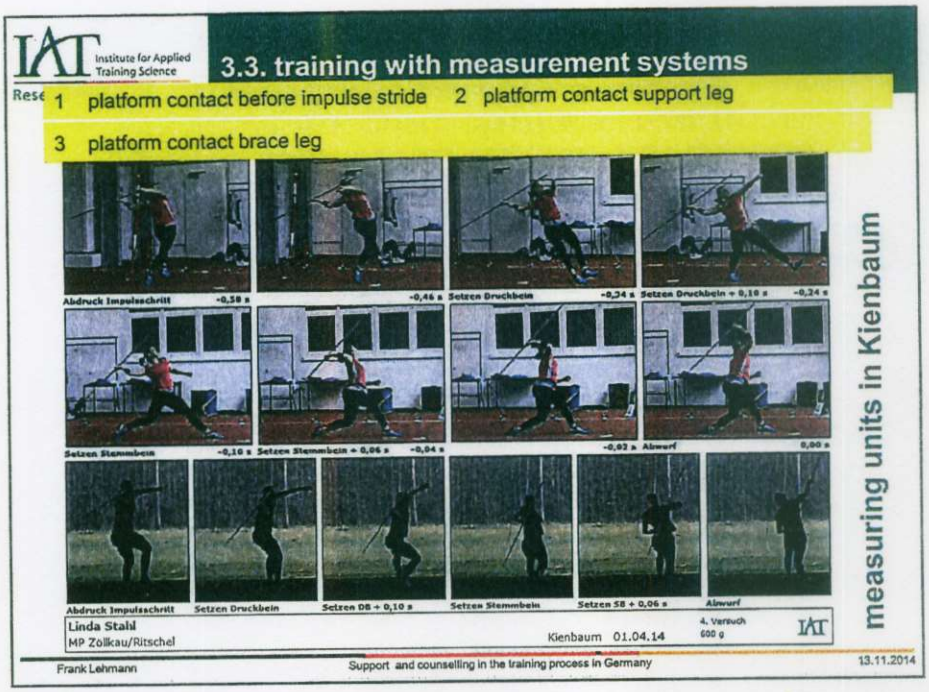
3.3. Training with measurement systems

1 platform contact before impulse stride 2 platform contact support leg

3 platform contact brace leg 4 javelin with acceleration sensor ("Tenso-javelin")



measuring units at the IAT (throw into a net)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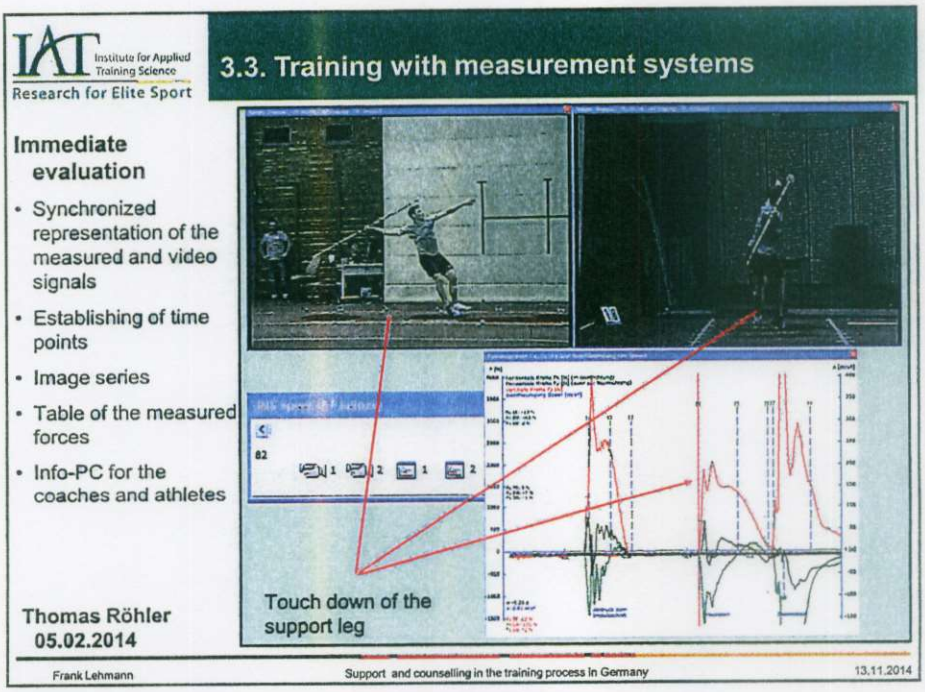
3.3. training with measurement systems
1 platform contact before impulse stride
2 platform contact support leg
3 platform contact brace leg
Abdruck Impulsschritt -0,58 s
-0,46 s Setzen Druckbein -0,24 s
Setzen Druckbein + 0,10 s -0,24 s
Setzen Stemmbein -0,16 s
Setzen Stemmbein + 0,06 s -0,04 s
-0,02 s Abwurf 0,00 s
Abdruck Impulsschritt
Setzen Druckbein
Setzen DB + 0,10 s
Setzen Stemmbein
Setzen SB + 0,06 s
Abwurf
Linda Stahl
MP Zollkau/Ritschel
Kienbaum 01.04.14
4. Versuch
600 g
IAT
measuring units in Kienbaum
Frank Lehmann
Support and counselling in the training process in Germany
13.11.2014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3.3. Training with measurement systems
Immediate evaluation
• Synchronized representation of the measured and video signals
• Establishing of time points
• Image series
• Table of the measured forces
• Info-PC for the coaches and athletes
Thomas Röhler
05.02.2014
Touch down of the support leg
Frank Lehmann
Support and counselling in the training process in Germany
13.11.2014

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3.3. Training with measurement systems

- Discussion of the individual deficits and reserves.
- Illustration of the corresponding parameters and courses.
- Motion correction (active cooperation with coach and athlete).







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3.3. Training with measurement systems

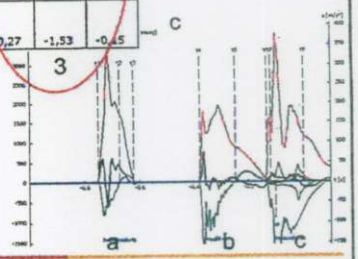
Representation of the ground reaction forces

Dynamometrie				SPEERWURF						IAT		
05.02.14 IAT Leipzig				Thomas Röhler						15. Versuch (952-g-Speer)		
Bewegungsposen		Zeit [s]	Zeitdauer [s]	maximale / mittlere Kräfte z [N]		x [N]		y [N]		Geschwindigkeitsänderung z [m/s]	x [m/s]	y [m/s]
Impuls-schritt 0,140	Setzen (t1)	-0,720										
	Fx=0 (t2)	0,643	0,077	1939	1539	-1018	-298	515	272			
	Lösen (t3)	-0,580	0,063	1904	1084	216	134	498	294	0,74	-0,14	0,44
Flug			0,220									
Druck-bein 0,260	Setzen (t4)	-0,360										
	Fx=0 (t5)	-0,256	0,104	2484	1626	-1744	-592	872	196			
	Lösen (t6)	-0,100	0,156	1265	560	327	98	188	32	0,33	-0,50	0,27
t7-t6			-0,020									
Stemm-bein	Setzen (t7)	-0,120				-3673						
	Fx_min (t8)	-0,096					-1112	277	106			
	Abflug (t9)	0,000	0,120	4092	1056					0,27	-1,53	-0,45

1 2 3

a b c

(1) time structure
(2) amount of forces (average and maximum in different phases)
(3) changes of CG-velocity during the contact phases a, b und c



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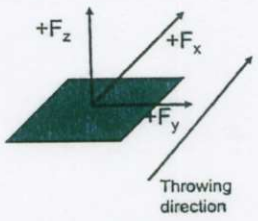
3.3. Training with measurement systems

Ground reaction forces

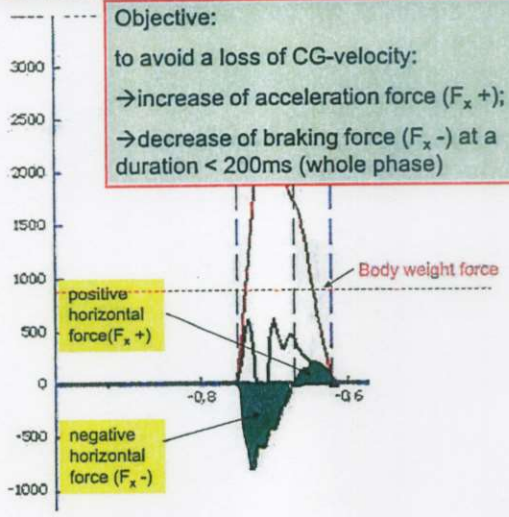


Objective:

to avoid a loss of CG-velocity:

→increase of acceleration force (F_x +);

→decrease of braking force (F_x -) at a duration < 200ms (whole phase)



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3.3. Training with measurement systems

Example of an intervention on the measuring units - M. d. Z.

Deficit: activity of the support leg;- C.G. at the touch down of the support leg too much behind the foot- → too long duration of the delivery stride→ too much loss of C.G. velocity

Situation in 2008

Hallesche Werfertage 2008 (81,20m)

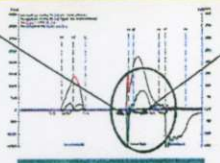
time of delivery stride: 260ms

Touch down support leg

Dynamo grams at the intervention

Touch down support leg +0.10s

Period of training with measurement systems (2009/2010)



time of delivery stride: 180ms

→ consolidation/implementation into the competition movement

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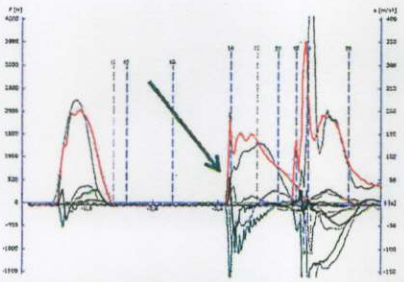
3.3. Training with measurement systems

abilities are reflected in the javelin movement- comparison of two athletes



activity of the support leg C.H. (colored TDSL→ TDBL: 180ms; Amortization: 139ms- 66N average horizontal force in concentric phase) versus C. O. (gray; TDSL→ TDBL: 200ms; Amortization: 80ms- 196N average horizontal force in concentric phase)

Results of the drop jumps (44cm falling height):

C.H. contact time: 136ms; Index 0,89 (short contact time, but not enough concentric activity)
C.O. contact time: 157ms; Index 1,03 (both at a good level)

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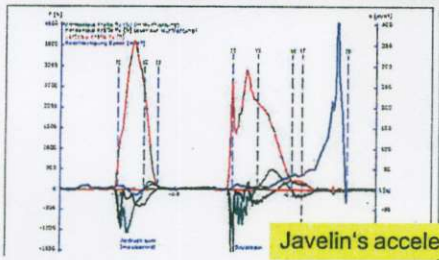
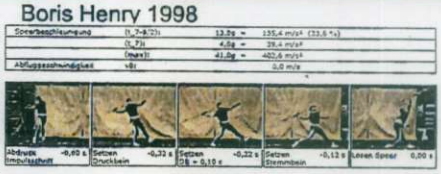
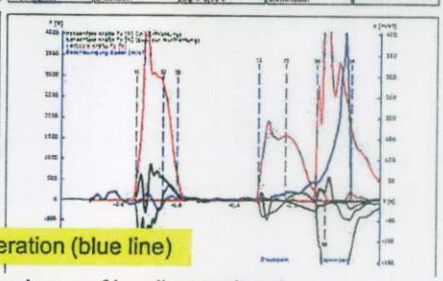
3.3. Training with measurement systems

Matthias de Zordo 2011



Boris Henry 1998





Javelin's acceleration (blue line)

Requirements:
- more than 400 m/s² maximum of javelin acceleration;
- less than 33 % (1/3) of the maximum in the middle between TDBL (touch down brace leg) and release (→good quality of the delay of throw)

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3.4. Support and counselling in main training camps

Analysis of top-performances: many of the German javelin throwers have deficits in the quality of the release

athlete	n	from/to	release speed [m/s]	angle of release [degree]	angle of attitude [degree]	angle of yaw [degree]	angle of attack [degree]
S.N.	15	2005-2009	24,7±0,6	32,3±2,0	41,4±1,9	13,4±2,3	9,0± 2,3
L.S.	19	2005-2011	23,1±1,1	34,5±2,2	46,8±4,0	10,2±1,8	12,3±3,1
K.M.	22	2005-2011	22,7±1,3	36,7±2,9	41,9±2,3	10,0±2,7	5,2± 1,8
C.O.	18	2005- 2009	24,7±0,7	38,0±2,8	39,6±4,7	15,8±5,3	1,5± 2,6
						Require-ment: <10 Grad	Require-ment: < 5 Grad

Can we improve this ability in throwing training by the use of feedback (instant information about the release parameters)?

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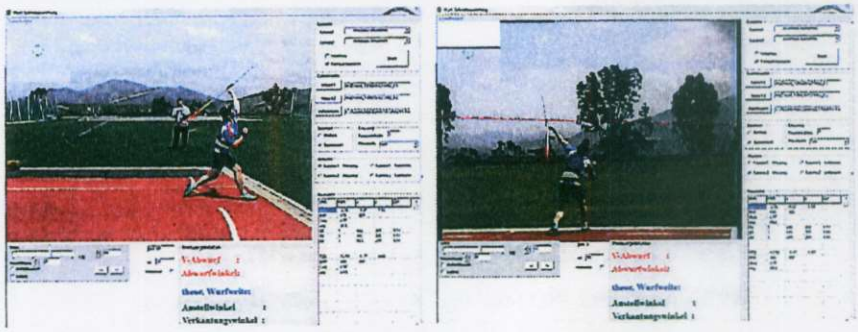
3.4. Support and counselling in main training camps

A special technology was developed at the IAT (WIESE/DRENK) to measure the important parameters after every throw („Throw-immediate evaluation"). 30-45s after every throw we obtain the results. Two hardware synchronized video cameras (50Hz) are necessary.



An exact and proved calibration was necessary in the preparation of these training units !

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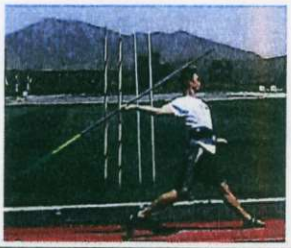
3.4. Support and counselling in main training camps

Training camp Chula Vista 2011

Besides five German top-throwers A.Thorkildsen and T.Pitkämäki were included partially.
On average of all 142 analyzed attempts we found a angle of release of 35,0 degrees, an angle of attitude of 33,1 degrees and an angle of yaw of 9,1 degrees.

	n	Speed of release [m/s]				angle of release [°]				angle of attitude [°]				angle of yaw [°]			
		ø	Min	Max	s	ø	Min	Max	s	ø	Min	Max	s	ø	Min	Max	s
all	142	23,6	18,5	28,4	± 2,1	35,0	16,7	40,4	± 3,3	33,1	13,6	40,6	± 4,0	9,1	0,3	18,4	± 3,9
male	86	24,6	19,6	28,4	± 1,9	35,0	16,7	40,4	± 3,8	33,9	13,6	40,6	± 4,5	10,8	2,6	18,4	± 3,8
female	56	22,1	18,5	23,8	± 1,2	35,1	23,3	39,2	± 2,5	31,8	19,9	38,1	± 2,8	6,6	0,3	11,6	± 2,6



On average a good quality of the release parameters was found!

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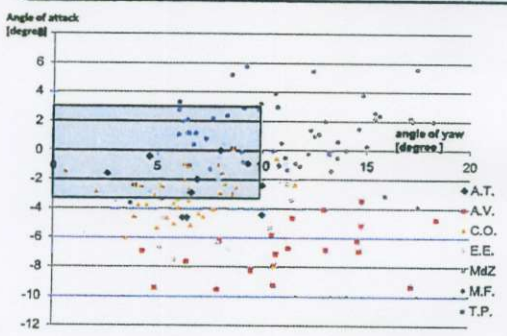
3.4. Support and counselling in main training camps

The individual evaluation was quite different. 76 of the 142 throws (53,5%) had a good quality in the release parameters (C.O. 90%; M.d.Z. 88%, A.T. 100%, T.P. 75% but A.V. 12%).



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3.4. Support and counselling in main training camps

Training camp Albufeira 2013

We continued this training in the following years - more athletes were involved. By using this system and the feedback in the throwing training we could reach a better quality in the release parameters at some athletes (for example T. R.)

name	date	throws	Percentage of throws in a good quality
C.O.	29.04.2013	10	80,0 %
	04.05.2013	19	80,0 %
C.H.	25.04.2013	18	11,1 %
	29.04.2013	15	33,3 %
S. M.	29.04.2013	10	40,0 %
I.E.	25.04.2013	17	5,9 %
M. d. Z.	02.05.2013	18	88,9 %
T. W.	29.04.2013	15	73,3 %
T. R.	30.04.2013	14	71,4 %
B. S.	25.04.2013	14	42,9 %
	30.04.2013	12	66,6 %
C. E.	02.05.2013	10	20,0 %

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4. Actual deficits and problems

- Think about the used equipment (used cameras; image frequency, HD-quality).
- Health management especially in men.
- Better team building (for example training camps).
- Reserves in the planning and evaluation of a training year under the responsibility of the federal coaches.
- Under the view of research: Use of statistical methods in top-performance sport?
- A lot of inquires from other track and field events in Germany - we cannot be satisfied.
- Diagnostics and training of relevant coordinative abilities.

Actual questions:
– optimal relation between muscle tension and flexibility;
– changes of the javelins acceleration in the course of a year.

- Development of new training equipment/devices.

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5. Summary and conclusions

- Our work and support have proven themselves and are estimated as effectively (coaches and athletes).
- The most important things of our support are: **estimation/evaluation/hints and conclusions for the German throwers in their training).**
- More feedback from all coaches, to ensure that they have understand the hints and conclusions and that they implement them in their training.
- Important: The most ideas and exercises and other possibilities come from the coaches. Most of top-athletes participate consciously.
- We constantly look for new developments in other countries too (for example BAS-Trainer).
- A lot of abilities we need at top-athletes must take a greater account in the juniors and youth training in the throwing events.
- Increasing globalization means increasing international exchange of experiences; (How can we manage it without decrease of the successes of the German throwers).

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Many thanks for your kindly attention!

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Gefördert durch:
Bundesministerium des Innern
aufgrund eines Beschlusses des Deutschen Bundestages

An Institute of the Association IAT/IfES e. V.