"Throws Dynamics"

Lessons Gleaned from World Leading Biomechanists and Biomechanics Projects

USTFCCCA Symposium

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Dynamics

The branch of mechanics concerned with the motion of bodies under the action of forces.

Warning!!

- Beware of conformational bias
- Utilize deep study of new trends and reports
- Sample diverse practitioners and projects
- Realize some of the classics and old guys weren't that far off
- Beware of marketing and internet **gurus**
- Be careful with inferences

Motor Learning and Biomechanics

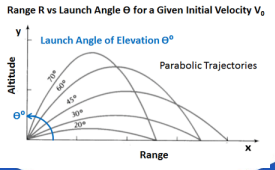
Motor learning is a change, resulting from practice or a novel experience, in the capability for responding. It often involves improving the smoothness and accuracy of movements.

Biomechanics is the movement science field that applies the laws of mechanics and physics to human performance, in order to **gain a greater understanding** of performance in movement events through modeling, simulation and measurement.

They are not one and the same!

Factors Influencing Distance: The 10,000 foot view!

- Release Velocity; cost/benefit factors
- Angle of Release; how is it obtained?
- Height of Release; a synchronized result



Games Theory- a study of strategic decision making.

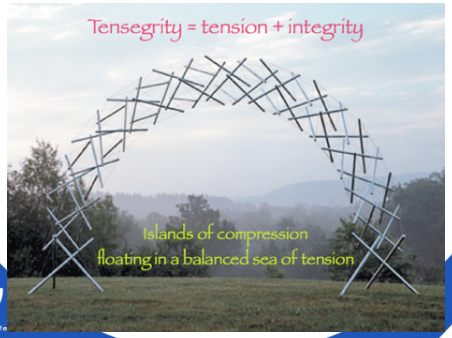
Strategies

- Leverage variables to gain distance
- Lever and Axes systems
- Timing systems, alarm theory
- Momentum
- Speeds
- Support Phases
- Flight Phases
- Pathways of implement and athlete

Virus Detection Paradigm

- Build spectral patterns that allow for identification of most pressing or worst virus.
- Search for "Trigger Viruses".
- Let go of myopic searches and see things in a more fractal, geometric manner.
- Keep "Cause and Effect" analysis at the forefront.

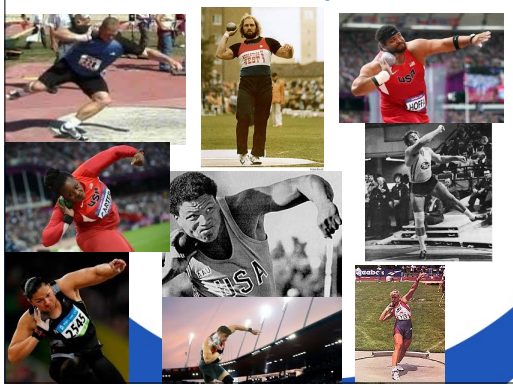
Tensegrity Factors, an Overlooked Phenomena in Technical Change



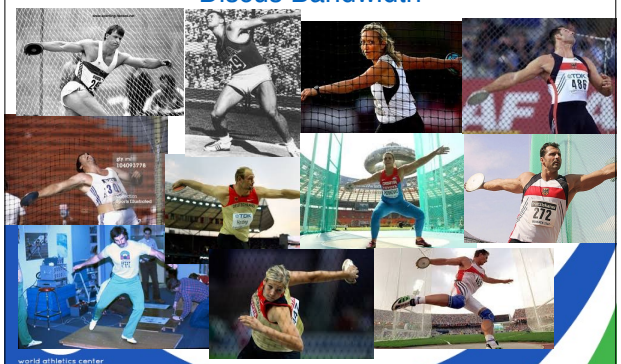
Motion Analysis: What to Watch and Cue

- Inter-athlete study
  - –gender, training age, cultures, evolutions
- Intra-athlete study
  - –far throws, poor throws, weather issues, evolution
- Event History and Evolutions
  - –film, studies, interviews, reports and texts

Bandwidth of Styles: Shot Put



Discus Bandwidth

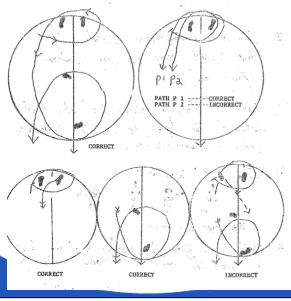


Hammer Bandwidth

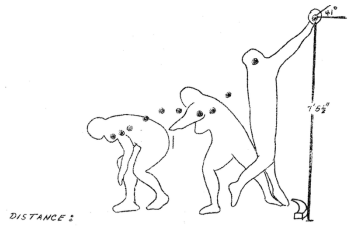
Javelin Bandwidth

Kinematics and Kinetics of the Throws

- Path of the implement: linear undulations and orbitals
- Discus:

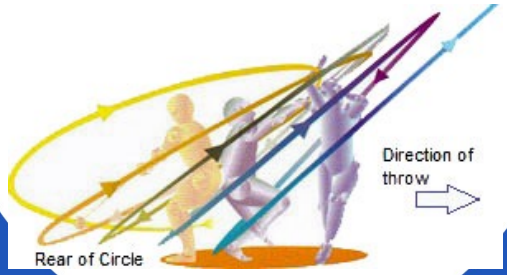


Shot Put

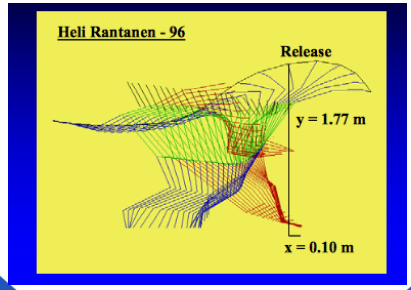


DISTANCE:
1. PATH OF SHOT – SIDE VIEW
2. ACCELERATION OF SHOT
3. ANGLE OF RELEASE
4. HEIGHTS OF RELEASE
5. RELEASE VELOCITY

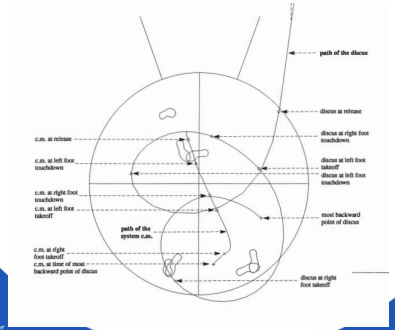
Hammer



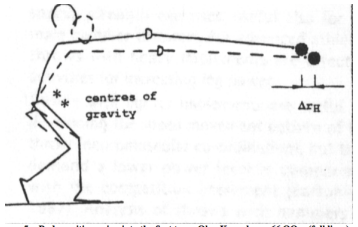
Javelin



Athlete Center of Mass - Discus



Athlete Center of Mass



gure 5: Body position going into the first turn: Olga Kuzenkova, 66.OOm (full lines) a sition of the target technique (broken lines)

Translational/Linear versus Rotational Factors

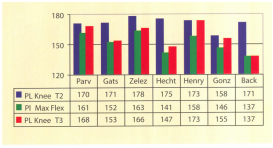


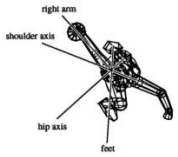
Figure 5: Knee angle of the braking leg (PL) at t1, maximum flexion at t3.

Athlete	Hip Axis Rotation (°)		Shoulder Axis Rotation (°)		Differenc Shoulder/Hip (°)	Difference Shoulder/Hip (°)
	t1	t2	t1	t2	t1	t2
Parvianen	141	107	165	133	24	26
Gatsioudis	182	114	180	135	-2	21
Zelezny	170	114	181	132	11	18
Hecht	151	135	194	156	43	21
Henry	148	138	171	139	23	1
González	124	122	188	154	64	32
Backley	135	111	162	143	27	32

Table 6: Relation between Hip and Shoulder axis rotation

Longitudinal, Shoulder and Hip Axes

- At various stages and support phases of the throw
- In relation to rotational factors
- 3 dimensional analysis critical



Head Positions

- Deviations in the frontal, saggital and transverse planes

Free Arm Movement Paths and Timing

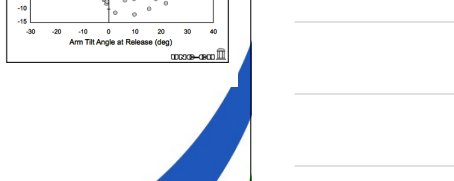
Propulsive swinging actions of the right leg and left arm in the back of the circle

Right leg action (RLA), average normalized angular momentum of the right leg about the vertical axis passing through the system c.m. (H_{RLA}), time (t_{RLA}) and average right leg radius (r_{RLA}) between the takeoff of the right foot and the takeoff of the left foot; left arm action (LAA), average normalized angular momentum of the left arm about the vertical axis passing through the system c.m. ($H_{LAA(max)}$), time (t_{LAA}), and average left arm radius ($r_{LAA(max)}$) between the instant when the discus reached its most backward point and the takeoff of the left foot; combined right leg and left arm action (RLLAA). The radii are expressed in meters, and also as a percent of standing height. Note: Some of the values in this table may not fit perfectly with each other, because of rounding off.

Athlete	Trial and meet (*)	Right leg					Left arm					Both
		RLA (Kgm²·10³/Kgm²)	H_{RLA} (s²·10³)	t_{RLA} (s)	r_{RLA} (m)	r_{RLA} (%)	LAA (Kgm²·10³/Kgm²)	$H_{LAA(max)}$ (s²·10³)	t_{LAA} (s)	$r_{LAA(max)}$ (m)	$r_{LAA(max)}$ (%)	RLLAA (Kgm²·10³/Kgm²)
Bisson	41 D86	22.3	54	0.41	0.279	15.1	26.8	29	0.93	0.331	28.7	49.1
Dumble	23 D86	24.0	71	0.34	0.271	14.7	34.3	43	0.81	0.330	28.6	58.3
Fitzpatrick	40 L94	23.2	60	0.39	0.256	13.3	37.4	39	0.96	0.324	27.3	60.6
Fitzpatrick	*62 D95*	*24.3*	*65*	*0.37*	*0.270*	*14.0*	*33.2*	*36*	*0.92*	*0.353*	*27.9*	*57.5*
Guthrie	28 L94	21.1	59	0.36	0.259	13.6	32.3	36	0.89	0.356	29.1	53.4
Granville	22 L94	34.0	75	0.46	0.322	16.4	45.5	37	1.22	0.422	31.7	79.5
Hart	57 D96	23.5	65	0.36	0.267	13.8	36.2	38	0.96	0.407	31.4	59.7
Haynes	24 D96	24.5	75	0.33	0.274	15.0	36.0	38	0.95	0.356	30.4	60.5
Heister	36 L94	15.7	49	0.32	0.215	11.2	35.0	38	0.93	0.360	29.3	50.7
Johnson	10 D96	23.0	59	0.39	0.274	14.2	36.7	34	1.09	0.567	29.4	59.7
Kleinhoff	34 D96	22.1	57	0.39	0.258	12.3	33.6	39	0.86	0.591	30.5	55.7
McPherron	08 D96	21.4	51	0.42	0.258	13.0	27.0	25	1.08	0.554	28.0	48.4
Mielke	22 D96	26.4	68	0.39	0.270	14.2	34.4	39	0.89	0.583	30.5	60.8
Muse	47 D96	34.3	72	0.34	0.264	14.3	33.4	41	0.83	0.562	30.5	57.7
Nail	15 D96	21.5	59	0.36	0.258	13.4	26.9	30	0.90	0.559	29.0	48.4
Patzu	01 L94	28.5	72	0.40	0.269	14.0	29.9	29	1.04	0.504	26.2	58.4
Prosser	09 D96	27.4	75	0.36	0.297	15.1	29.7	32	0.92	0.578	29.4	57.1
Schultz	59 D96	27.9	58	0.48	0.268	13.6	35.7	33	1.08	0.599	30.3	63.0
Scott	41 L94	28.1	67	0.42	0.278	14.4	35.1	33	1.05	0.631	32.7	63.1
Seiff	*27 L94*	*29.8*	*63*	*0.46*	*0.272*	*14.1*	*36.8*	*37*	*1.03*	*0.630*	*32.3*	*66.6*
Seiff	65 D96	31.8	66	0.48	0.285	14.8	37.0	34	1.09	0.596	30.9	68.8
Staat	25 D96	25.3	57	0.41	0.262	13.2	36.1	29	1.26	0.608	30.7	59.4
Sullivan	06 D96	20.0	82	0.35	0.291	15.7	31.0	36	0.85	0.464	26.2	60.0
Tveitas	39 D96	24.9	65	0.38	0.280	14.0	32.9	30	1.09	0.552	29.7	57.8
Washington	66 D96	20.9	96	0.32	0.305	14.3	33.0	44	0.75	0.596	32.1	54.0
Wirz	42 D96	26.3	75	0.38	0.307	16.3	33.3	38	0.88	0.556	29.4	61.6
Mean		24.9	65	0.38	0.270	14.2	33.8	35	0.97	0.567	29.7	58.7
S.D.		±3.9	±8	±0.04	±0.021	±1.2	±4.0	±5	±0.12	±0.056	±1.6	±6.5

Throwing Arm Movements

- Shoulder
- Elbow
- Hand



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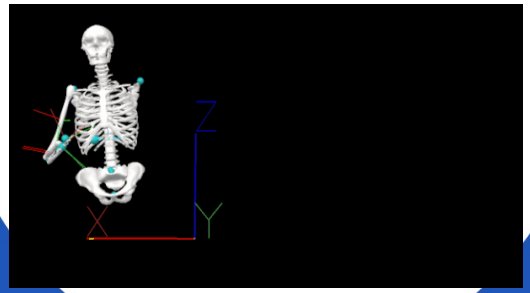
Javelin



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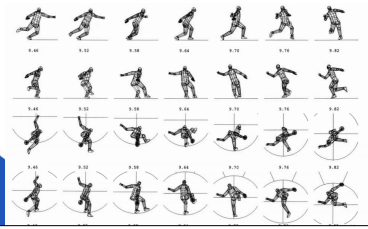
Hip, Knee and Ankle Factors

- Angles, ranges, congruency
- Pathways of movement
- Timing
- Support phase and flight phase factors



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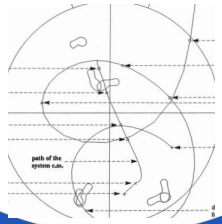
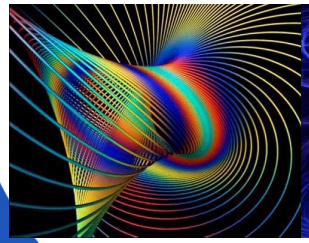
Longitudinal Foot Axis

- In double support phases
- In single support phases
- In flight phases



Elastic Energy Advantages



Spatial and Temporal Dynamics

Table 2. Duration of the single (S) and the double (D) support phases in the 1st, 2nd, 3rd and 4th turn (in seconds).

Rank	Athlete	Result	S1	D1	S2	D2	S3	D3	S4	D4	TOTAL
1	MUROFUSHI	82.01	0.30	0.32	0.24	0.22	0.22	0.18	0.24	0.24	**1.96**
2	TIKHON	80.00	0.32	0.32	0.22	0.28	0.22	0.18	0.26	0.24	**2.04**
3	KONOVALOV	77.14	0.36	0.28	0.28	0.20	0.26	0.26	-	-	**1.64**
4	KRUGER	75.53	0.30	0.36	0.28	0.24	0.26	0.20	0.28	0.24	**2.16**
5	PAPADIMITRIOU	74.13	0.34	0.32	0.24	0.24	0.26	0.22	0.24	0.28	**2.14**
6	STEACY	74.04	0.28	0.34	0.22	0.26	0.24	0.20	0.24	0.28	**2.06**
7	HARMSE	73.94	0.34	0.26	0.30	0.24	0.24	0.18	0.30	0.22	**2.12**
8	RENDELL	71.99	0.34	0.34	0.30	0.30	0.24	0.24	0.22	0.30	**2.28**
9	EPALLE	71.43	0.40	0.36	0.36	0.16	0.34	0.20	0.28	0.32	**2.42**

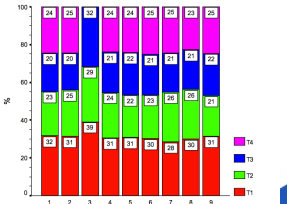


Figure 2. The duration of each turn (T) as percentage of the total duration of the turns. The athlete ranked 3rd (Konovalov, RUS) used 3 turns.

Temporal Dynamics-Discus

Optimum Temporal Rhythm

- Unwind ≥ 0.6 sec
- 0.45 sec ≤ Single support on the back ≤ 0.55 sec
- 0.08 sec ≤ Flight ≤ 0.12 sec
- 0.17 sec ≤ Single support in the middle ≤ 0.22 sec
- 0.15 ≤ Delivery ≤ 0.17 sec

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Preparation Phase or Windup

- Balance
- Rhythm and Timing
- Replication of program disc drives
- Elastic strength promotion
- Conservation of momentum
- Conservation of acceleration

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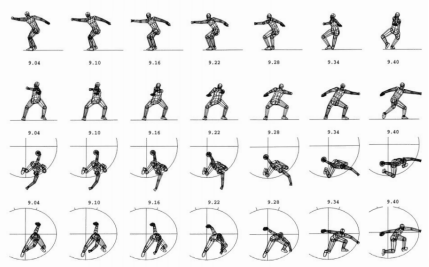
Preparation Phase or Windup



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Positive Movement Phase

- *Free* side dynamics
- *Throwing* side dynamics
- *Support* leg dynamics
- *Flight* phase dynamics
- *Free leg* or swing leg dynamics
- *Foot* positions and dynamics

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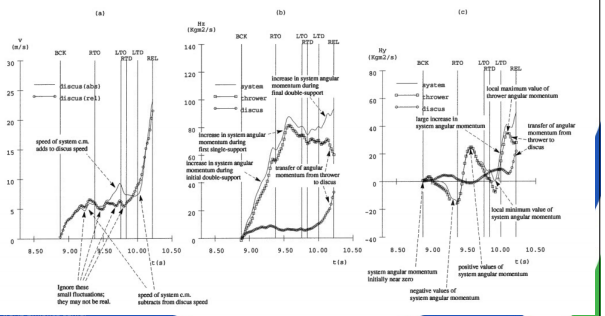
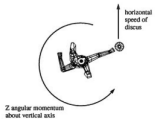
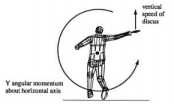
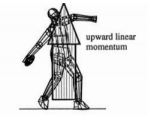
Support Phase/Flight Phase



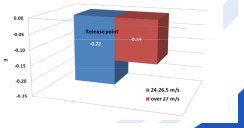
Delivery Phase Dynamics







Distance between the release point and toes of the front leg in horizontal direction
- Finnish male throwers 2004-2012:



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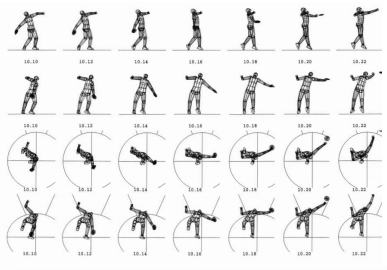
Delivery Phase Dynamics



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Follow Through Dynamics

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