Biomechanics II:

Analysis of Movement

An overview and advanced discussion of the effects of movement, with a focus on the technology available to analyze skills and support science-based instruction.

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Supporting the ART and BUSINESS of SCIENCE-based coaching.
Technique is largely determined by mechanical factors.

Some common technique tips…

1. Gut-Butt Connection
2. Alignment!
3. Two-head turn to the top.
4. …
5. …
6. …
In order to teach a new skill and/or coach an existing one, we must establish some sense of flow in movement/skill analysis.

**MECHANICALLY**, what do I see in the skill?

- Is it good?
- Is it bad?
- Is it important?
- How can I fix it?

**Why is it happening?**

- Is it mental?
- Is it physiological?

**Top 3 Precautions to Avoid Missing the Mark:**
1. Don’t Lose it in Translation.
2. Prioritize Feedback.
3. Focus on Critical Features (AP-MM).

**Is the body size APPROPRIATE?**

**Are the muscles SMART enough?**

**Are the muscles FUELED enough?**

*A prelude to... Deterministic Modeling.*
Deterministic Modeling shows relationships between the result of a performance and the factors contributing to it.

The method is used to:

Focus, objectify and prioritize training emphasis and feedback.

Improve understanding of factors contributing to sport performance.

Identify factors that are most sensitive to training/overtraining effects.

Guide equipment design and rule changes.

Guide quantitative research.

Critical Features describe specific body movements which may be observed in order to determine if the mechanical factors have been performed ideally.
Deterministic Modeling is a Three-Step Process:

Step 1 – Identify the errors associated with critical features.
• Determine mechanical factors affecting the execution of the skill.
• Identify true deterministic factors, i.e., those not directly connected to any lower factor.
• Eliminate factors athlete cannot affect in time frame being considered.
• Observe athlete performance on remaining factors.

Step 2 – Evaluate and prioritize the errors.
• Maximize impact subject to motivational needs.
• Important factors are those strongly related to the result.
• Sensitive factors are those that can change.
• Exclude errors that appear to be caused by other errors.
• Consider time frame.

Step 3 – Intervene via feedback, practice, training.

Implementation
Pre-requisites:
What makes a difference?
What can change?
How long might it take?
How do I go about it?

 TECHNOLOGY CAN HELP!!!
About 10 years ago, there was a study done on the characteristics most critical to successful completion of the triple axel.

Speed of rotation, jump height, jump distance were investigated.

Skaters with rotation speeds of 5 rev/sec or more were more successful in completing triple axels.

Jump heights were not appreciably different among singles, doubles and triples!

Take-offs and jump distances were shortest for triples, probably due to larger skids. Skid widths ranged from 1.25 to 3.00 inches.

Time to bring arms and legs into tightest position was a major factor in rotational speed.

The application of biomechanics principles minimizes “trial and error” coaching and fosters the development of effective teaching strategies and training programs that are specific to the unique needs of individual skaters and teams.
These values assume that the skater’s center of mass is at the same height at take-off and landing.

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PRINCIPLES OF ANALYSIS OF MOVEMENT

**Projectile Motion**

“An object that leaves a surface with both horizontal and vertical velocity will follow a parabolic or symmetrical arc-shaped pattern in the air.”

**TRANSLATION:** The up and down parts of the flight path of a skater’s jump will be symmetrical.

“The greater the height of the trajectory, the longer the air time associated with the parabola.”

**TRANSLATION:** The higher you go, the more time you get to spend in the air. (Imagine a water hose!)

The application of biomechanics principles *minimizes “trial and error” coaching* and fosters the development of effective teaching strategies and training programs that are specific to the unique needs of individual skaters and teams.
The specific flight path a skater follows is determined by the velocity and angle at take-off.

Important Factors:
- Approach speed ($V_H$)
- Upward press ($V_V$)

There may be a trade off between jump height and rotational velocity.

You need enough time to complete the rotations, pull in arms and legs, open to check out for landing, and to distribute rotations equally.

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<th>PRINCIPLES OF ANALYSIS OF MOVEMENT</th>
<th>Conservation of Rotational Momentum</th>
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| Rotational momentum quantifies the amount of rotational motion that a skater possesses about her axis of rotation (usually longitudinal axis). | Since rotational momentum remains constant…
| Rotational momentum is created during the entrance to a spin or during a jump preparation and take-off. | **If moment of inertia ↑, then rotational velocity ↓.**
| It combines both how fast a skater is rotating and the current body position: Rotational momentum = \( V_R \times \text{moment of inertia} \) | **If moment of inertia ↓, then rotational velocity ↑.**
| On the ice, rotational momentum is created when the forces the skater applies to the ice with her blade create a torque. | The greater the rotational momentum going into a jump or spin, the greater potential for rotational velocity during the jump or spin.
| Once in the air, however, there is no surface for the skater to push against, so rotational momentum remains constant from jump take-off until landing. | The best jump take-offs and spin entries are ones that convert horizontal velocity into vertical velocity and initiate rotation.
| The greater the rotational momentum going into a jump or spin, the harder it will be to pull the arms and legs into a tight position and hold it. | Enter strength, timing, skids, patterns, take-off movements, air position, etc.

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In 1999, a motion analysis program was developed at the University of Delaware. Technical, logistical and financial complications forced it closed.

The new motion analysis program continues to focus on the mechanical determinants of multi-revolution jumps:

- Body measurements (anthropometrics)
- Rotational energy at take-off (angular momentum)
- Body position in air (moment of inertia)
- Jump height (air time)

With support of the United States Olympic Committee and U.S. Figure Skating, the University of Delaware is reviving the program.

The new program boasts modern software and new personnel with the abilities to:

- Analyze critical features
- Assess revolution capacity
- Provide real-time analysis
- Suggest strategies
- Evaluate strategies
- Develop norms

Imagine all the “What if” scenarios!!
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