ROWING EFFICIENCY

Complex Biomechanical Diagnostics of Rowing on a Simulator

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1. INTRODUCTION & OBJECTIVES

In January, a complex diagnostic protocol was implemented to provide a holistic evaluation of rowers. The primary objective was to assess both physiological capabilities and biomechanical efficiency simultaneously.

> **differentiation:** This approach differentiates between "raw power" (the ability to generate high force) and "work capacity" (the ability to integrate force over time).

2. METHODOLOGY

The Protocol

Morphological Status: Body composition, anthropometry, spirometric lung volume assessment.

The Test: Continuous 9-min incremental test on rowing ergometer (after 30-min warm-up).

Load Definition: Based on individual aerobic threshold from prior measurements.

Recovery: 8-min phase monitoring HR drop, lactate, and VO2 dynamics.

Data Acquisition

Physiology: Gas exchange (VO2, CO2) via Cosmed system. Blood lactate samples at rest, finish, and recovery.

Biomechanics: High temporal resolution (100 Hz) capture system.

Synchronization: Precise sync of high-speed video with telemetric data (power, force, stroke length) with zero lag.

3. EXPERIMENTAL SETUP

Setup with standard ergo-handle

Setup with SmartRow handle

SmartRow handle

Visual Note: *The setup involves continuous monitoring of the athlete using the Cosmed gas analysis mask and real-time biomechanical feedback screens.*

4. ADVANCED ANALYTICAL METRICS

Force Curve Analysis

Definition: Relationship between Peak Force and Work per Stroke.

Topology: Analyzes curve shape (e.g., symmetric bell vs. triangular "peaky") to identify technical deficits like early force release.

Efficiency Ratio: Ability to maintain force throughout the drive phase.

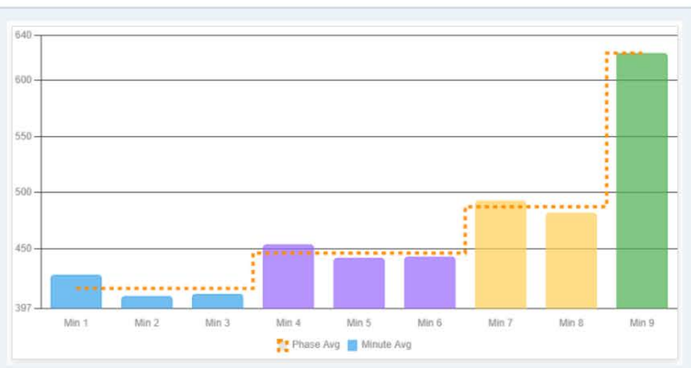
Variability & Stability

Poincaré Plots (SD1/SD2): Assess cycle consistency. SD1 indicates technical inconsistency; SD2 correlates with physiological fatigue.

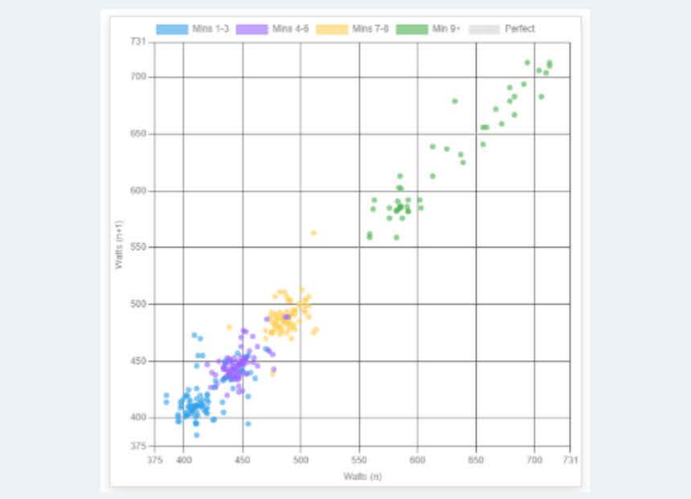
Rhythmic Stability (CV%): Normalized measure of rhythm stability. Lower values indicate higher movement automation and better energy efficiency.

5. RESULTS: POWER & STROKE

Power and stroke rate



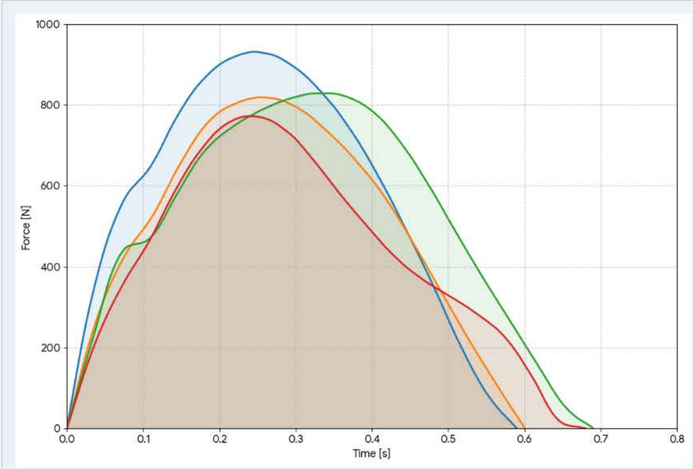
Average Power by each minute



Data was linearly interpolated to allow for continuous analysis. Charts display the incremental increase in power output and dispersion (scatter) over the 9-minute test.

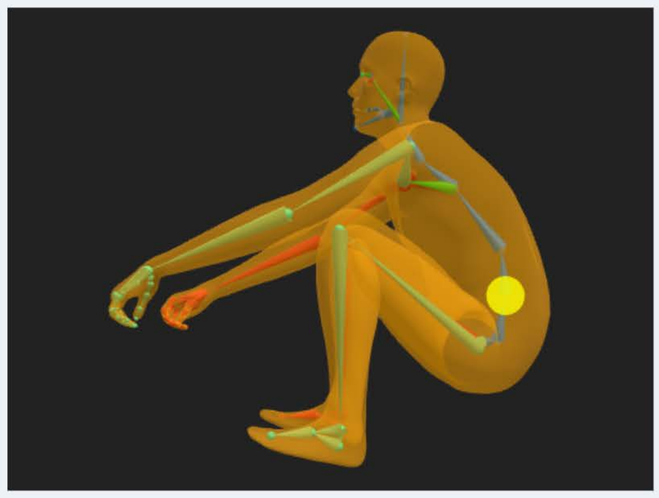
5. RESULTS: TOPOLOGY & BIOMECH

Force Curve Topology



Illustrates average force per stroke. The specific shape indicates the efficiency of power application.

Biomechanical Modeling



3D skeletal modeling is used to visualize body kinematics and efficiency.

6. CONCLUSION

The results provide a crucial basis for optimizing the training process and correcting technical anomalies. By analyzing advanced metrics like curve topology and stability (SD1, SD2), coaches can address technical deficits that standard average values might miss.

Force-Impulse Discrepancy: Comparative analysis reveals that athletes with identical peak forces can exhibit significant disparities in total work (up to 145 J variance), confirming that the area under the force curve—not peak magnitude—is the primary determinant of effective propulsion.

Topological Diagnostics: Distinct curve geometries successfully categorize athletes into "explosive" phenotypes (steep, triangular profiles) versus "work-capacity" phenotypes (broad, trapezoidal profiles), facilitating targeted training interventions.

Kinetic Chain Anomalies: Analysis identifies specific technical deviations, such as "shoulders" on the ascending curve limb, which signal a premature leg drive and kinetic decoupling at the catch phase.

Efficiency vs. Magnitude: While raw power outputs vary significantly (>900N vs <700N), data indicates that smoother, symmetric "bell-curve" topologies yield superior biomechanical efficiency ratios regardless of total power generation.

REFERENCES

1. Concept2 RowErg
2. SmartRow
3. Cosmed CPET
4. Concept2 Logbook

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