Coaching Clinic - Summer 2011

Muscular Power and its Application in Swimming Training

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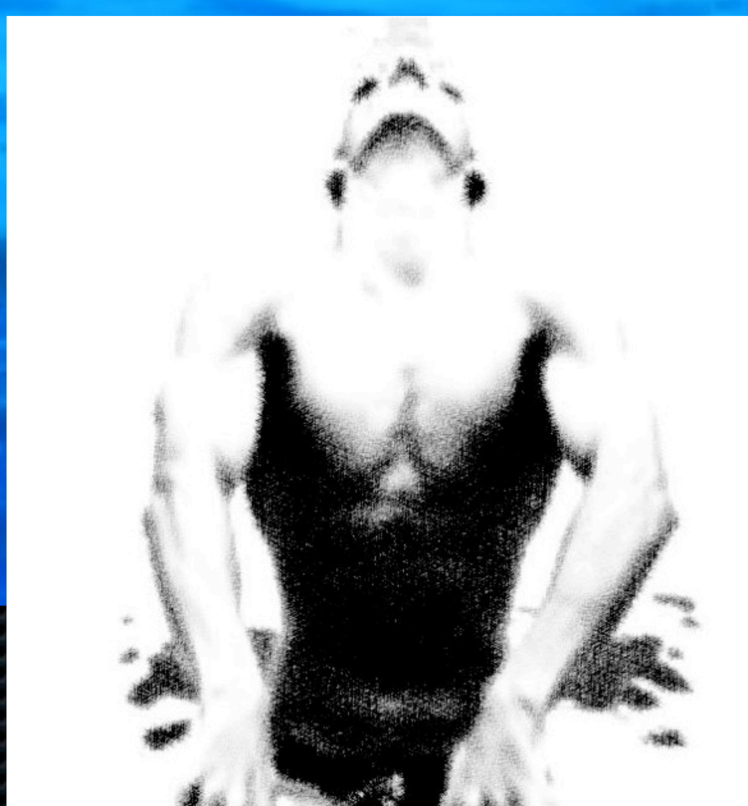
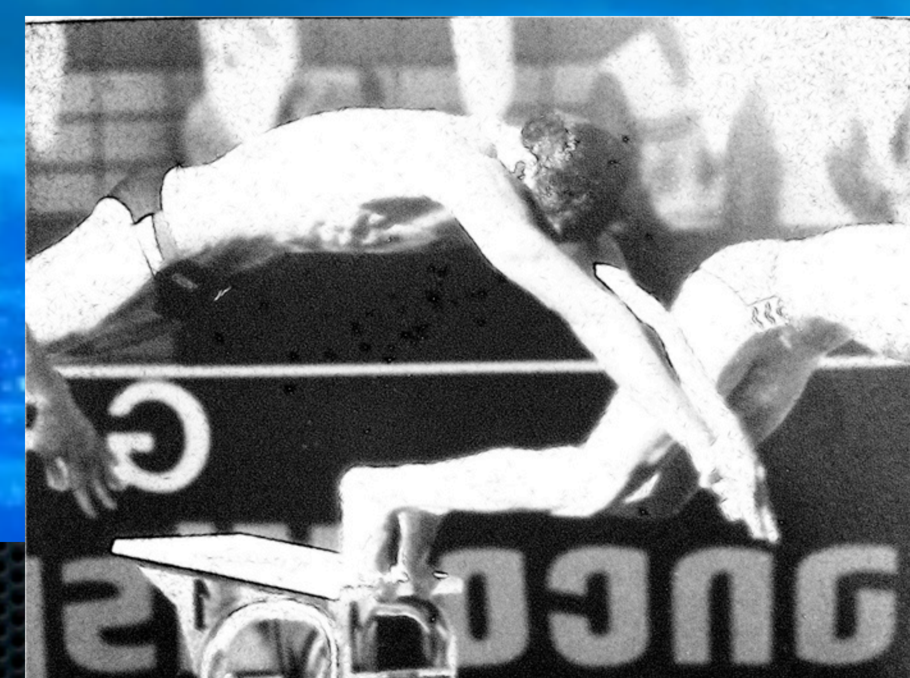
Is Swimming a Power Sport ?





Contents

Basic Definitions

We know the load

It derived from velocity

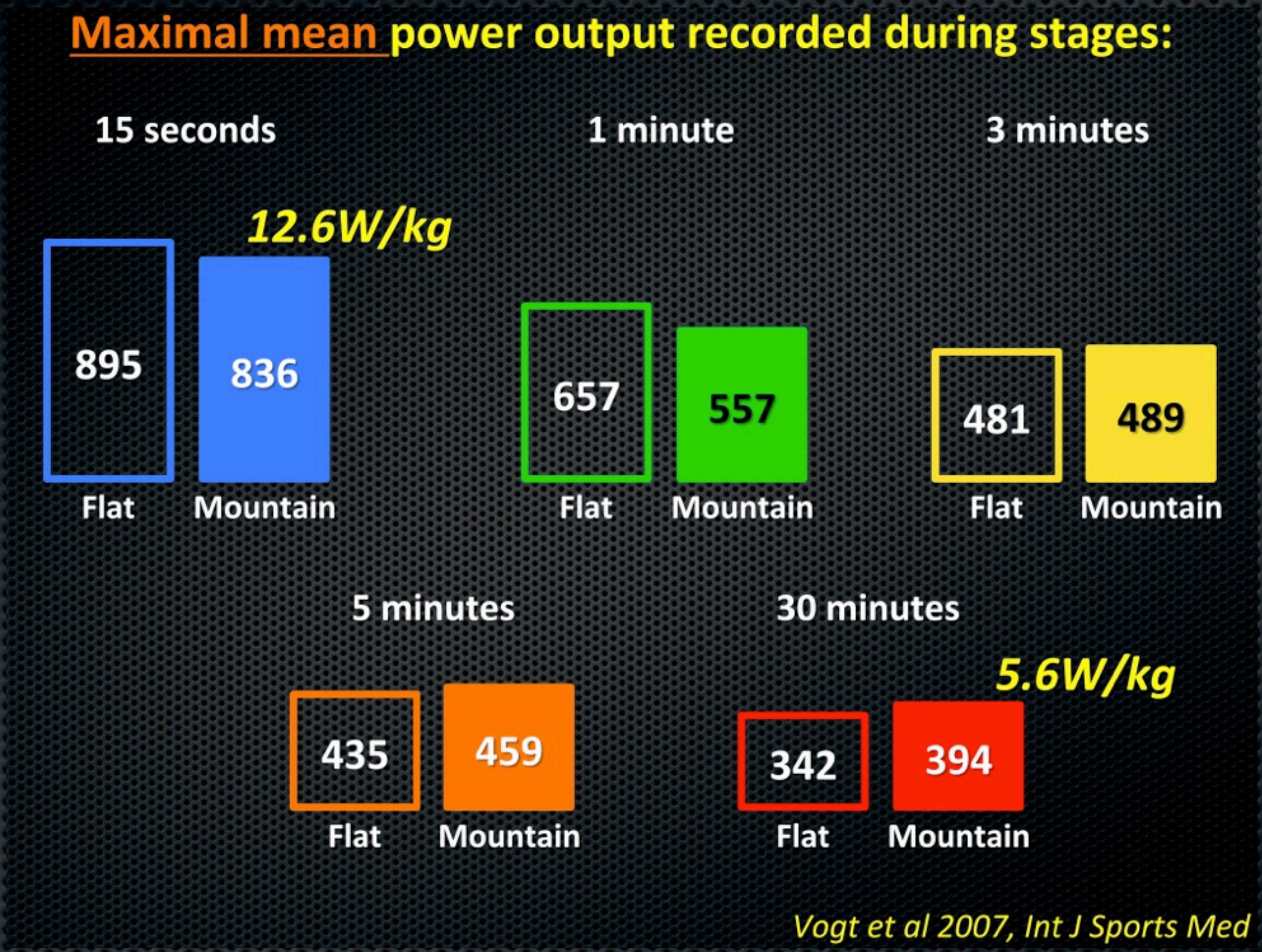
- ➡Force = m a (newton - N)
- ➡Work = F s (joule - J) --> energy
- ➡Power = Work / t = F s / t = F v (watt)

We measure the velocity
Wired linear encoder (1000Hz)

Strength training of Power Training?

- ➡1. The load is the key factor
- ➡2. A rational combination of Velocity and Strenth

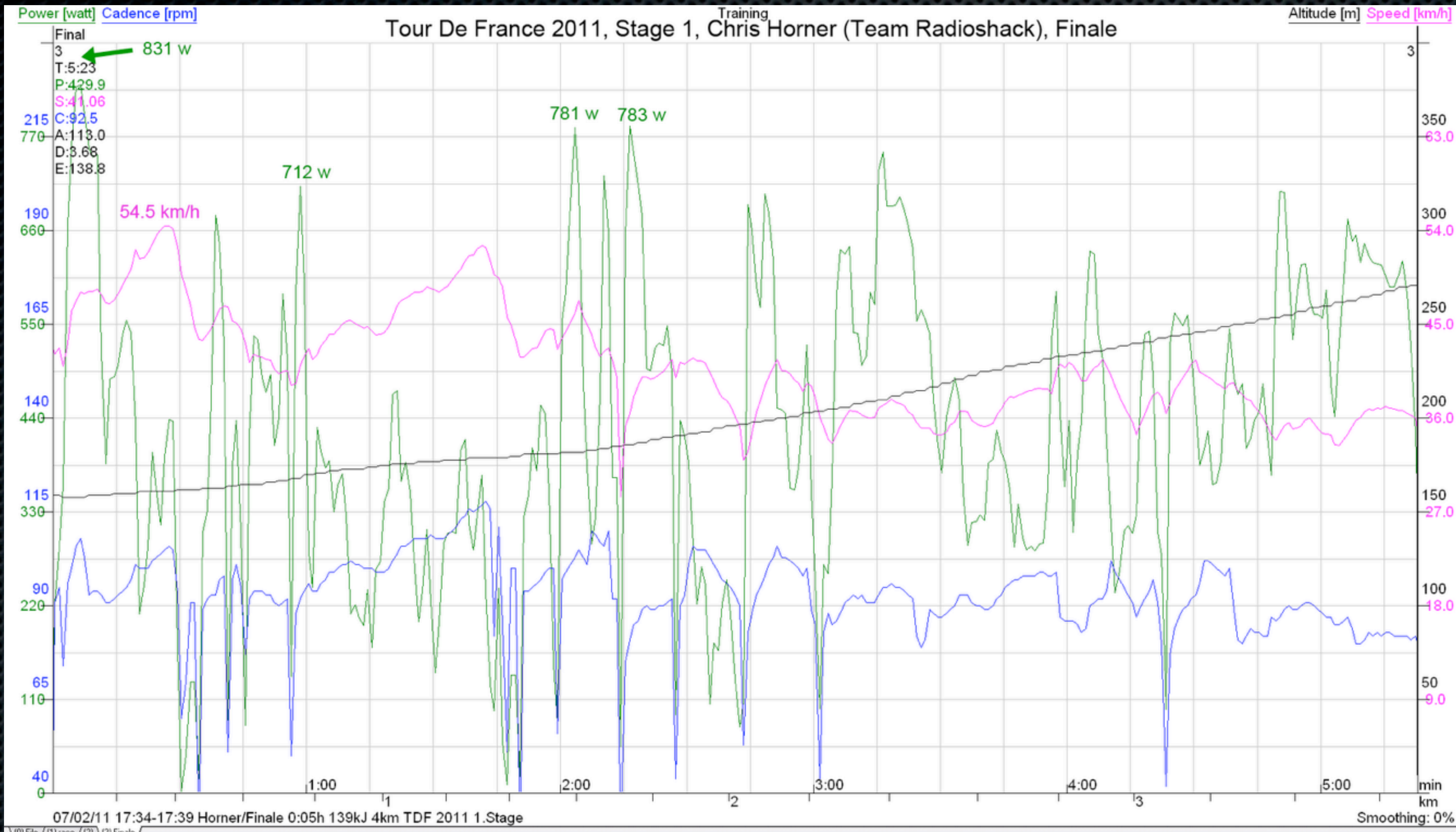
Some references: "Tour de France"



from THE SCIENCE OF SPORT
Scientific comment and analysis of sporting performance
Ross Tucker, PhD & Jonathan Dugas, PhD

http://www.sportsscientists.com/

Some references: “Tour de France”-2



from **THE SCIENCE OF SPORT**
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Cycling...

➡Is a good example where:

- higher power means better performances

➡As a cyclic sport, should swimming be similar?

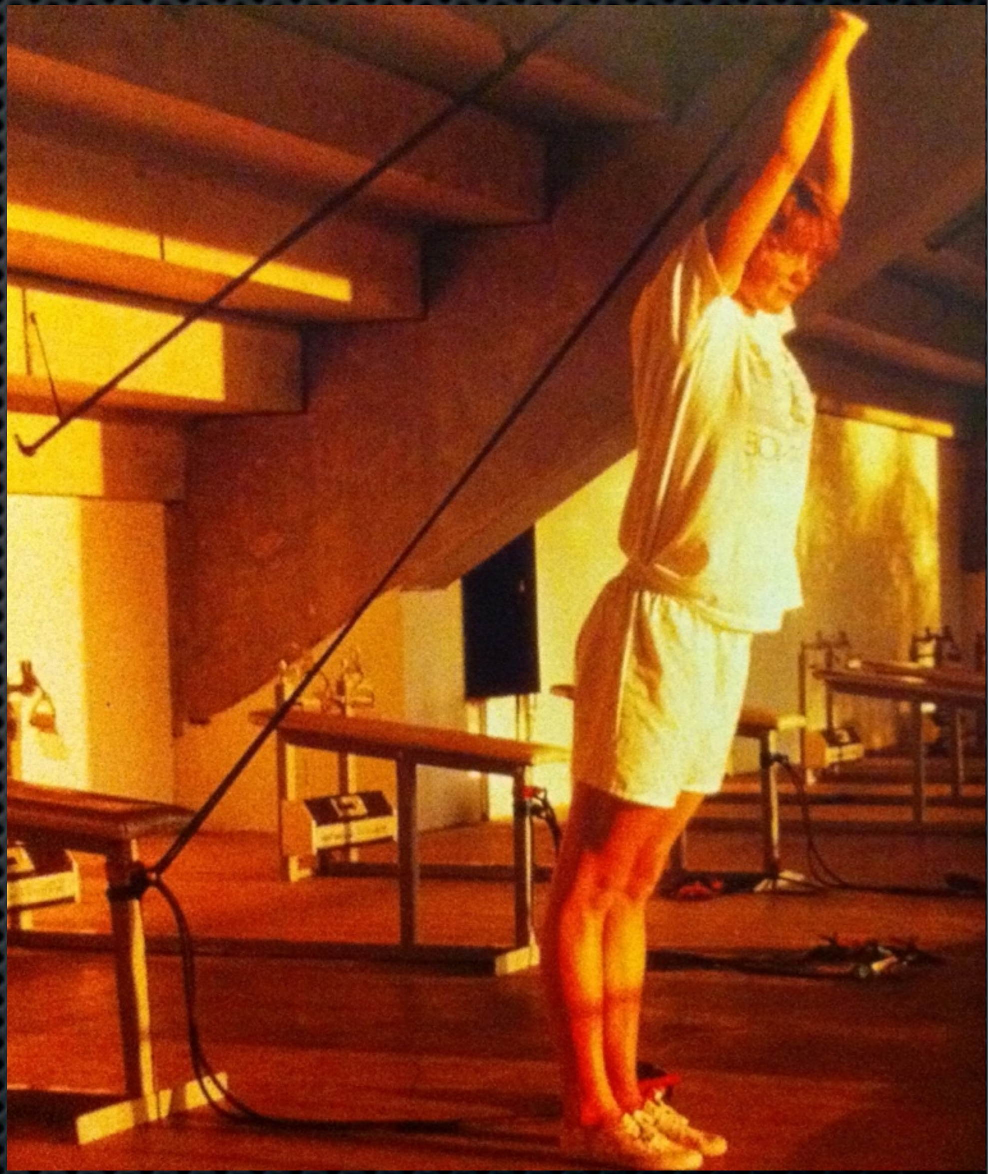
Strength training evolution

➡From LOAD oriented training

- UNITS: mass * number of repetitions * series

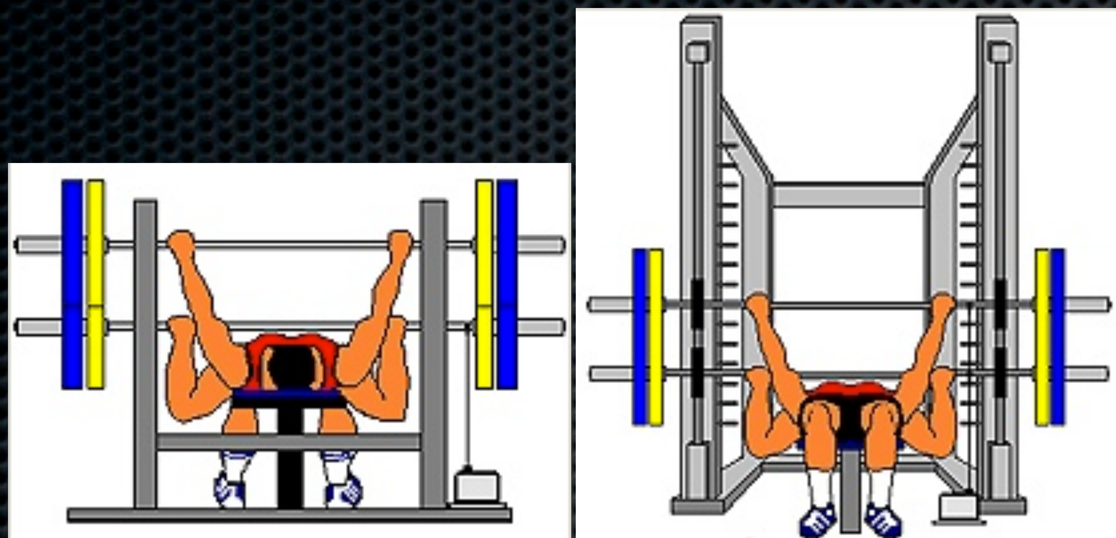
➡To POWER oriented training

- Added UNITS: mean, peak and instantaneus:
- *velocity*, acceleration, force,

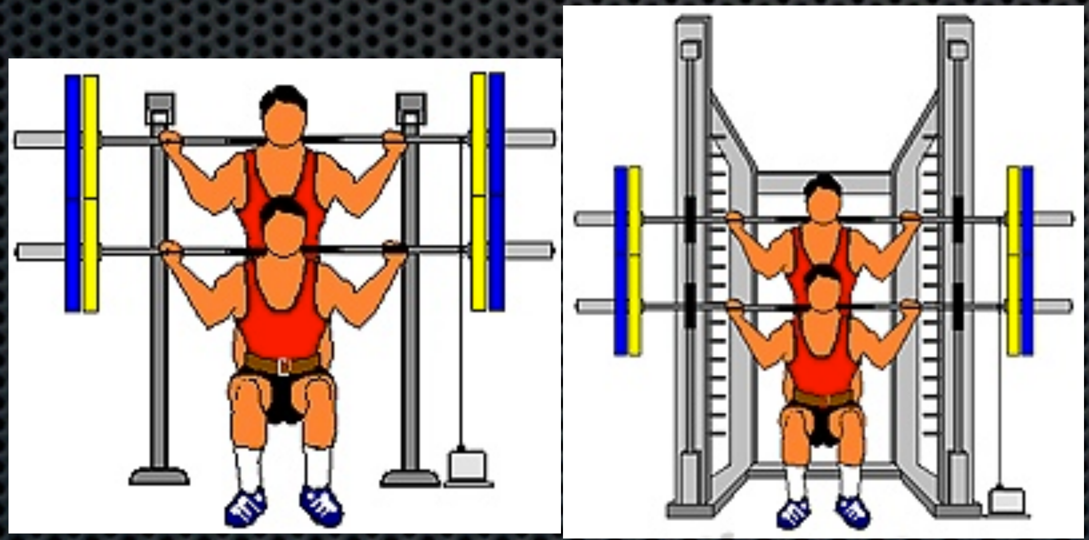


Recent research simplifies everything to velocity plus loads

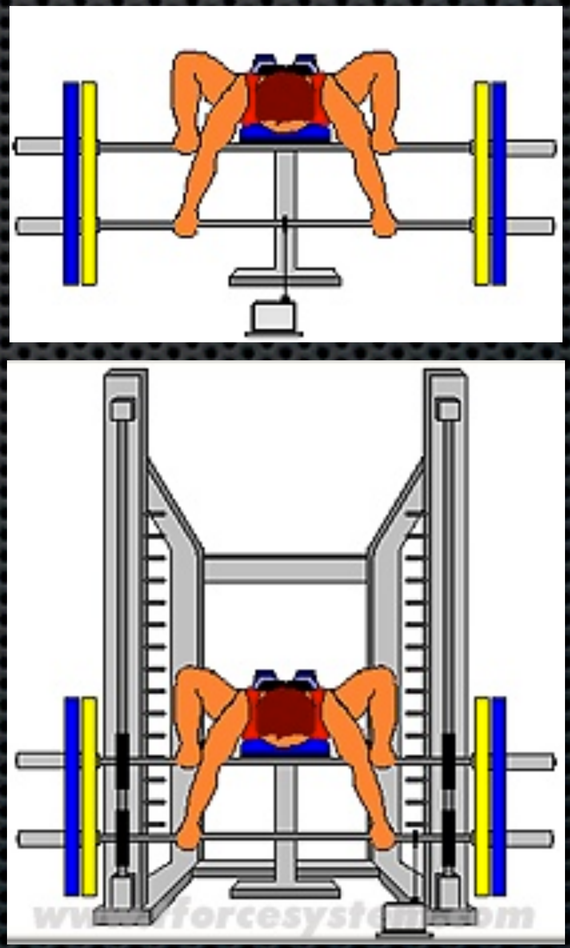
Typical Strength Exercises



Bench-Press



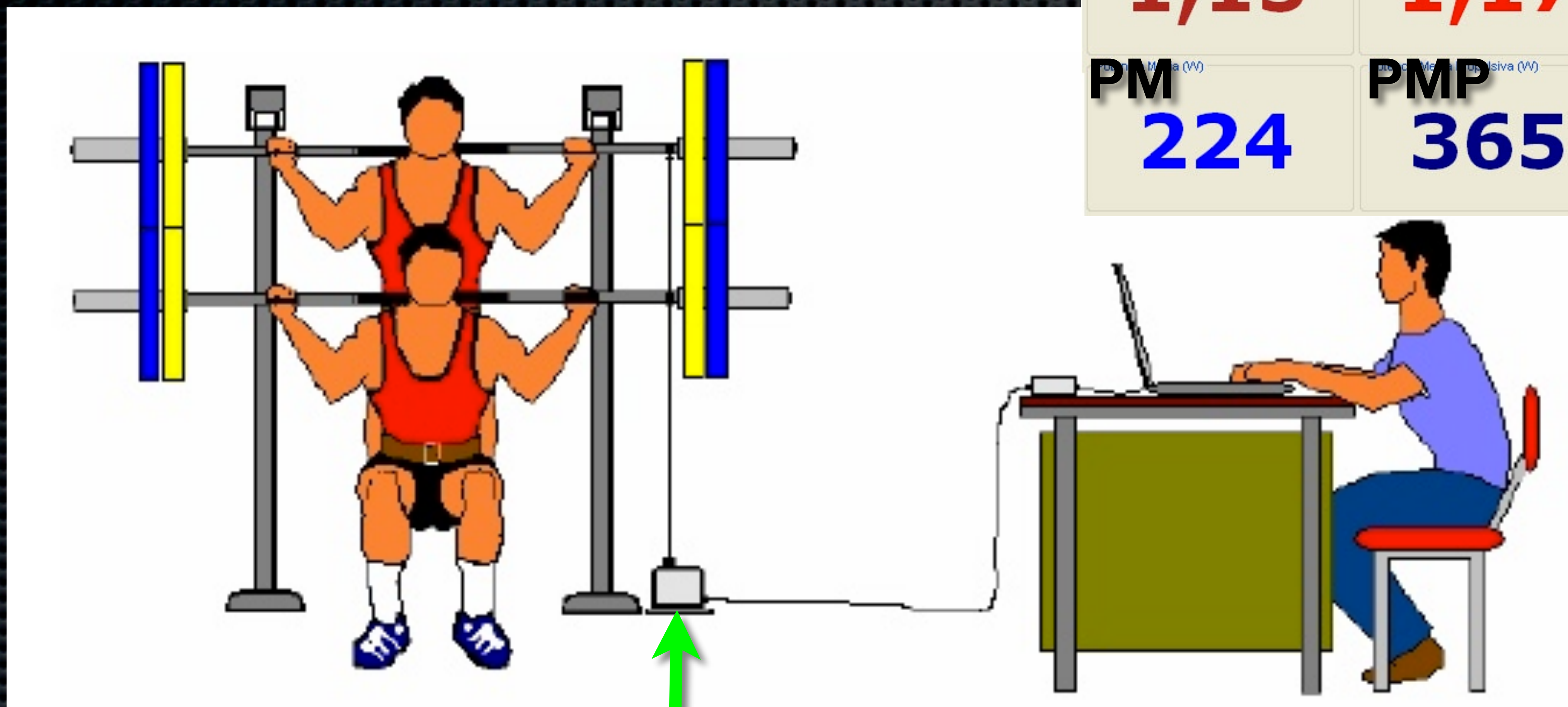
Semi-squat



Bench-Pull

How the power is measured?

VM	VMP	VPeak
1,15	1,17	2,31
PM	**PMP**	**PPeak**
224	365	799



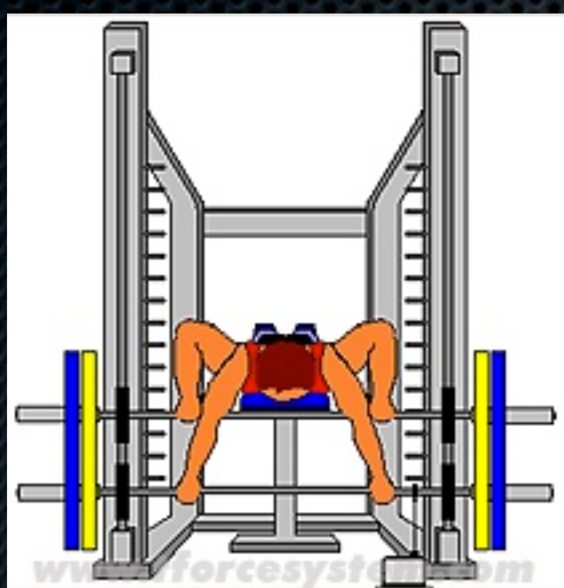
$$F = m \cdot (a + g)$$

$$P = F \cdot v$$

$$I = \int F dt$$

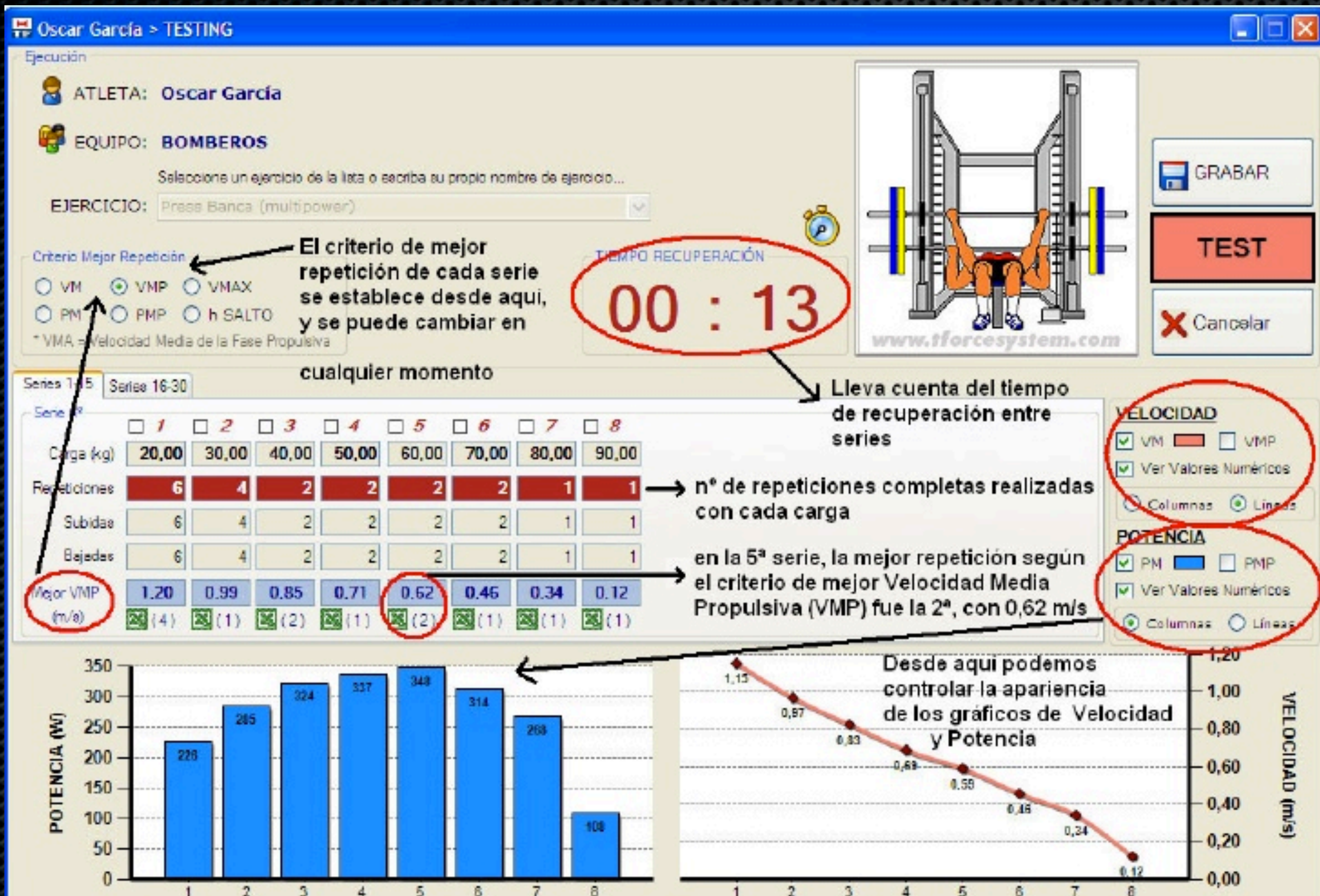
T-FORCE
DYNAMIC MEASUREMENT SYSTEM

Recording Sample



Bench-Pull

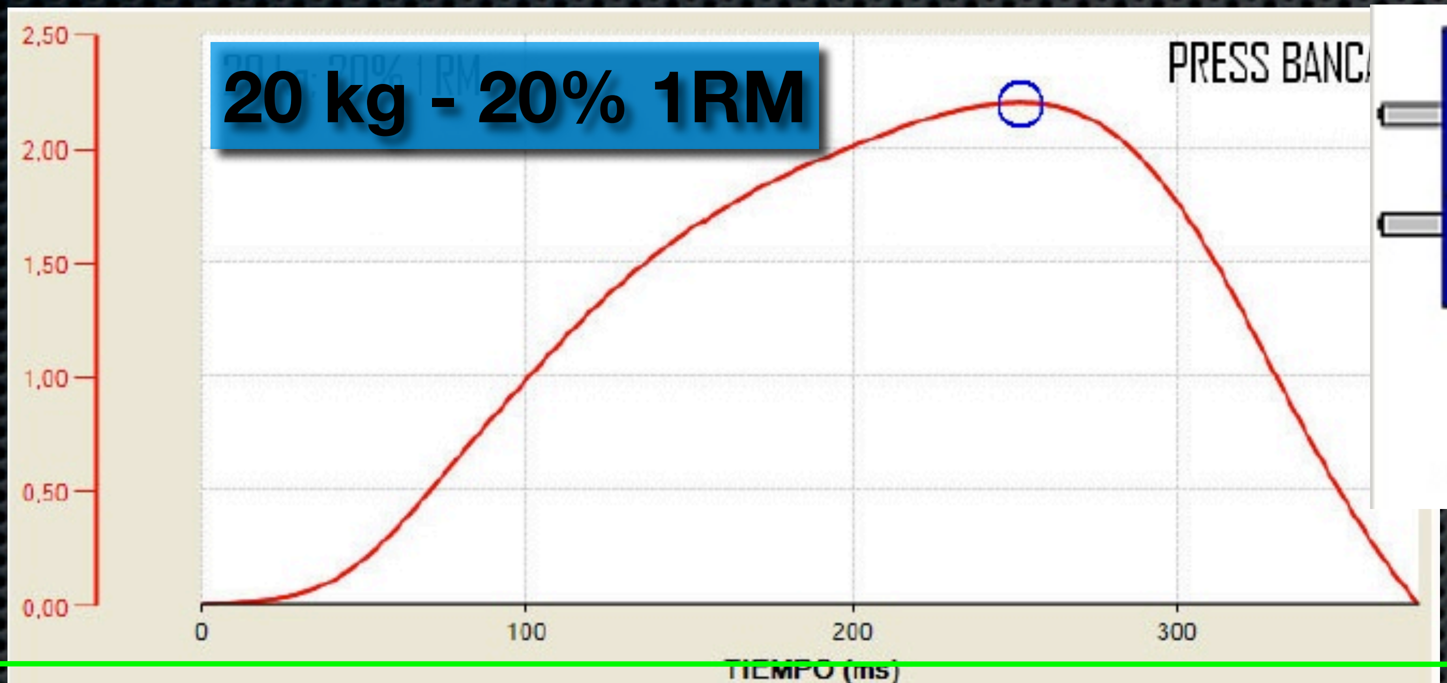
Reporting results...

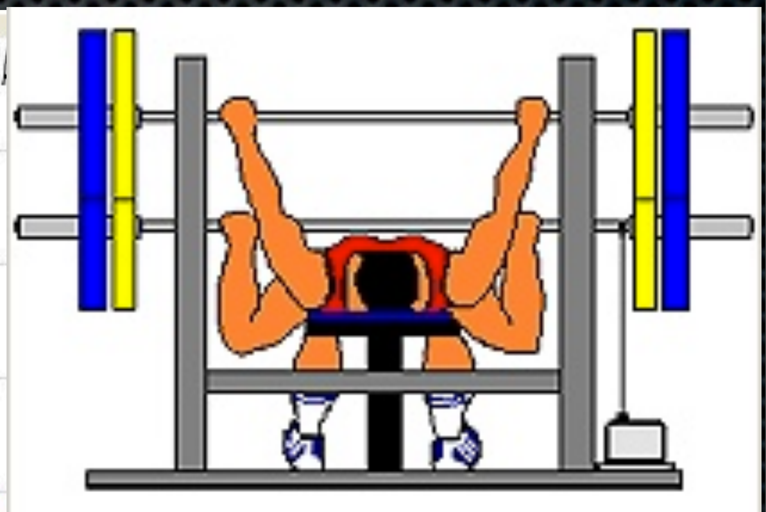


Velocity differences - Load

2.5 m/s

0 m/s

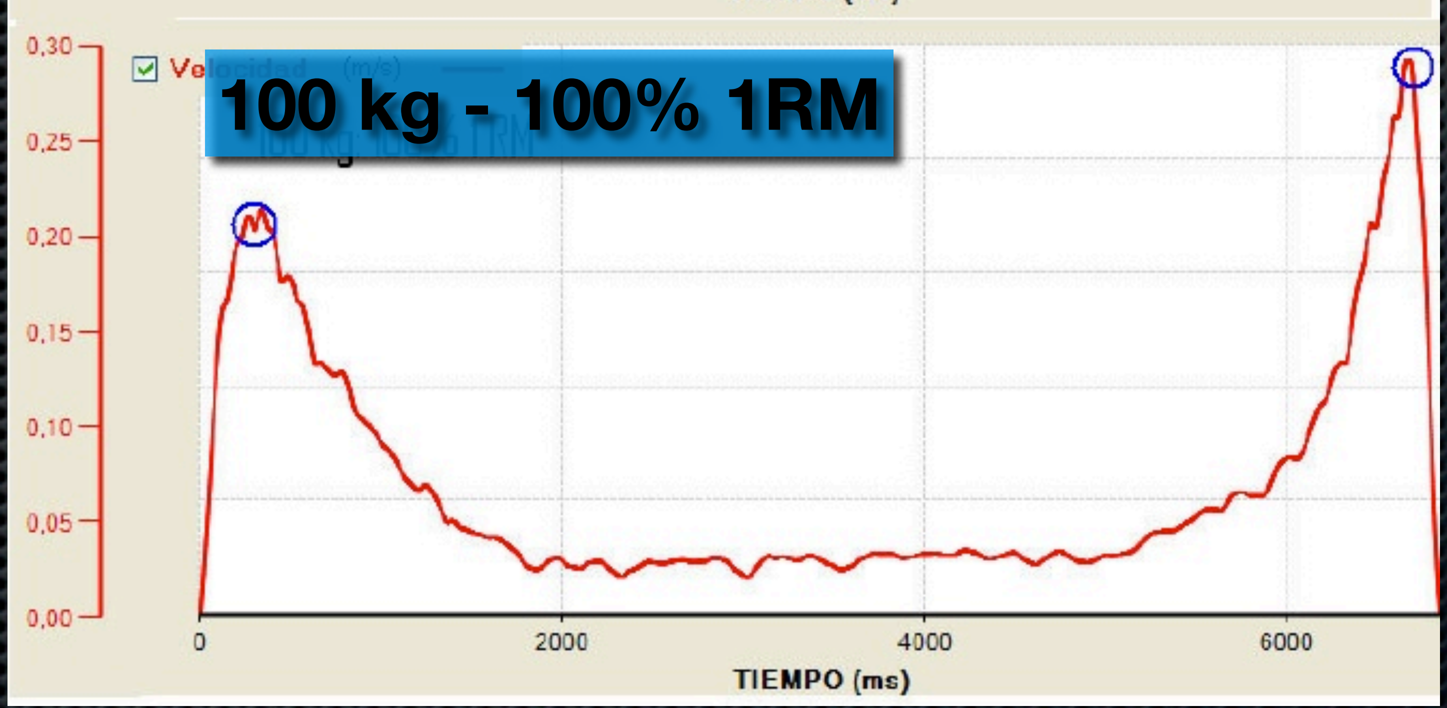




Bench-Press

0,3 m/s

0 m/s



Muscular Power Measurement

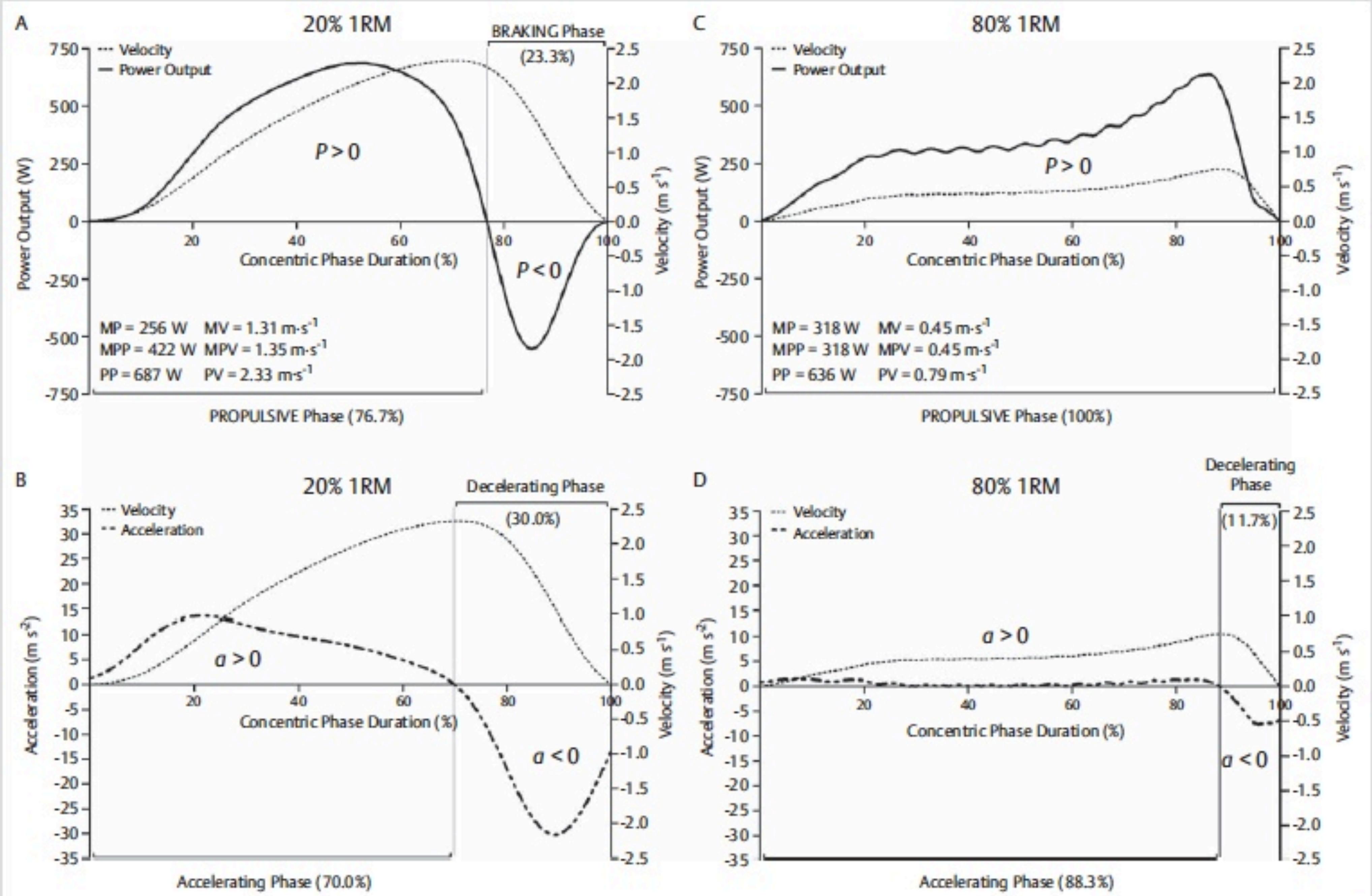


Fig. 1 Example of power output, velocity, and acceleration curves obtained when lifting a light (20% 1RM) versus a high (80% 1RM) load for a representative subject. The relative contribution of the propulsive and braking (**A**, **C**) or the accelerating and decelerating (**B**, **D**) phases to the total concentric duration in the bench press is shown. MP = Mean Power, MPP = Mean Propulsive Power, PP = Peak Power, MV = Mean Velocity, MPV = Mean Propulsive Velocity, PV = Peak Velocity, *P* = Power Output, *a* = Acceleration.

Sanchez-Medina L et al. Importance of the Propulsive Phase in Strength Assessment. Int J Sports Med 2010; 31: 123–129

Velocity (m/s) and Load (%1RM)

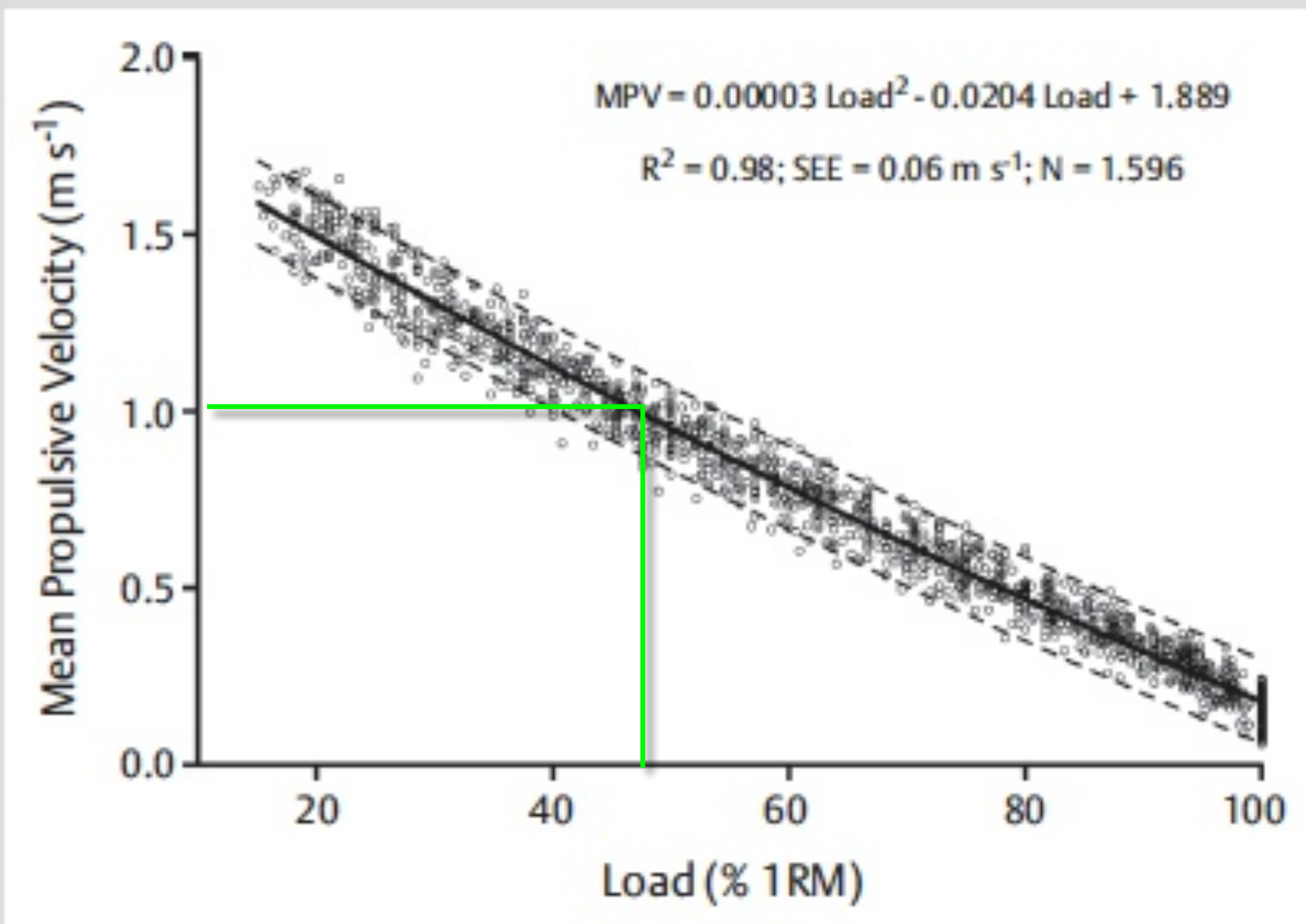
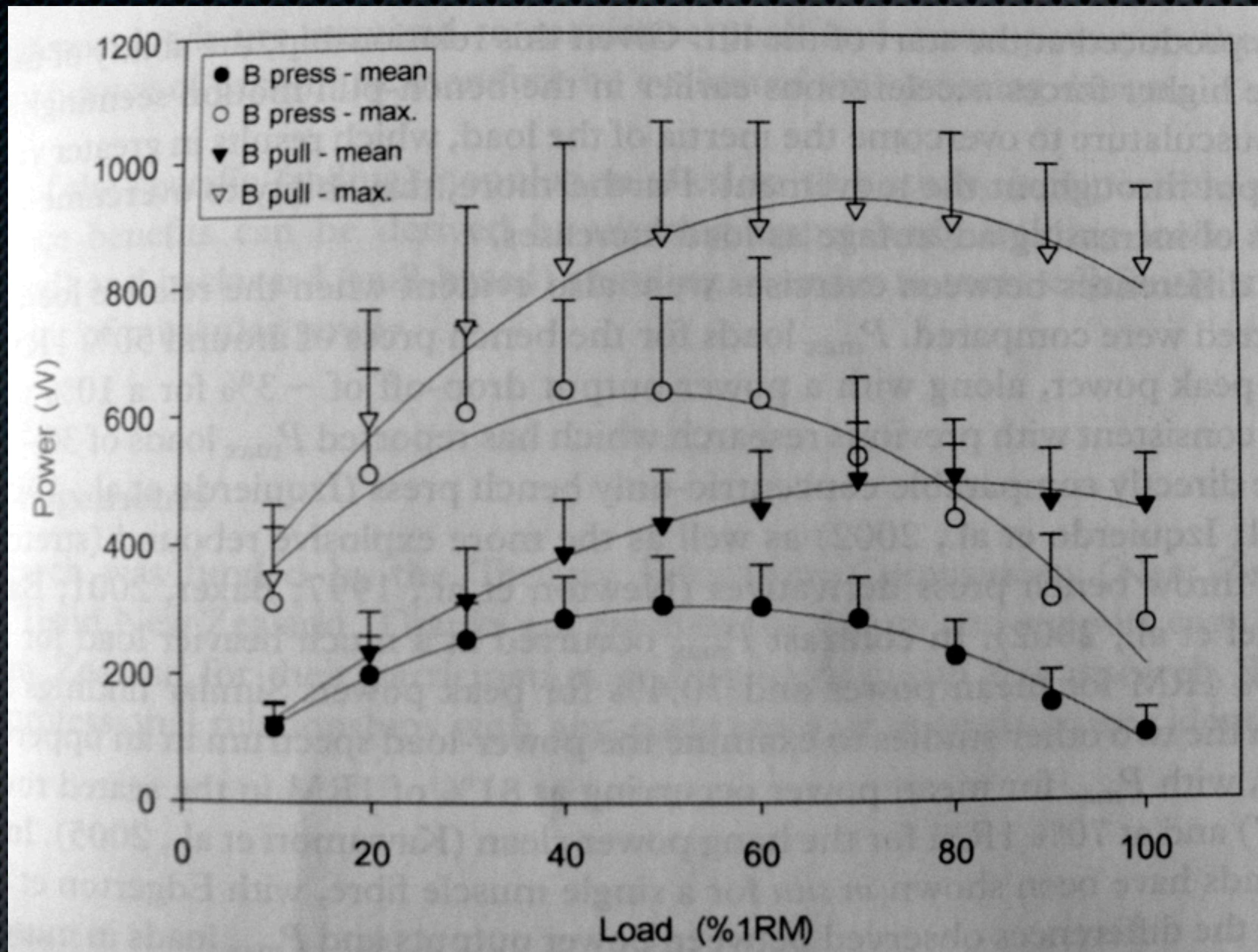


Fig. 1 Relationship between relative load (% 1RM) and MPV directly obtained from 1 596 raw data derived from the 176 incremental tests performed in the BP exercise. Solid line shows the fitted curve to the data, and the dotted lines indicate limits within which 95 % of predictions will fall.

We advocate the use of Mean Propulsive Velocity because it better represents the true neuromuscular potential of a subject against a given absolute load, instead of Mean Concentric Velocity

González-Badillo JJ. Sánchez-Medina L. Movement Velocity as a Measure of Loading Intensity… Int J Sports Med 2010; 31: 347–352

Load versus Power Example



Sports Biomechanics
September 2009; 8(3): 245–254

Kinematics and kinetics of the bench-press and bench-pull exercises in a strength-trained sporting population

SIMON N. PEARSON[1], JOHN B. CRONIN[1,2], PATRIA A. HUME[1], & DAVID SLYFIELD[3]

Muscular Power Measurements - 2

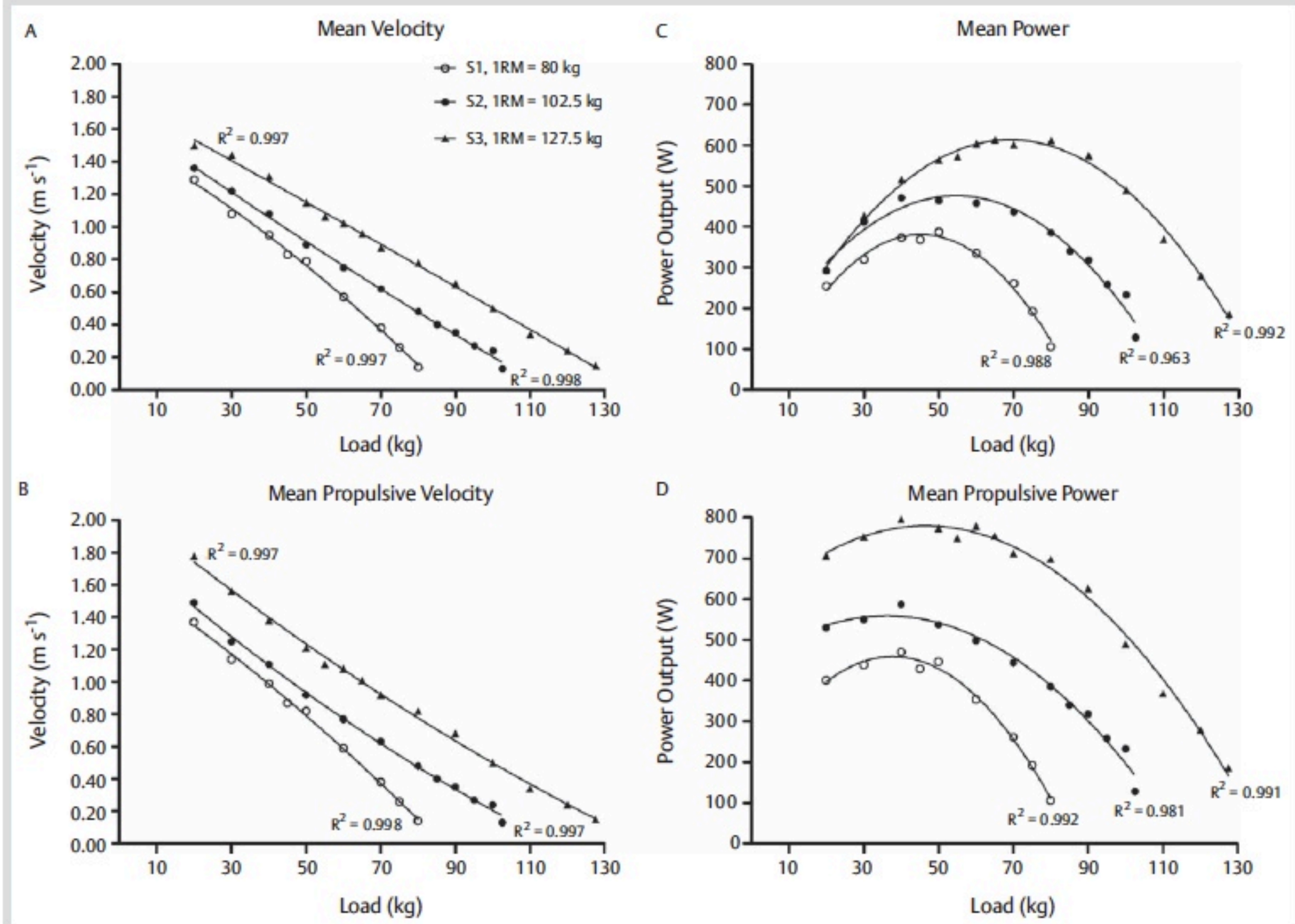


Fig. 3 Examples of the load-velocity and load-power relationships for three representative subjects with different levels of maximum strength. Mean concentric velocity and power output values (**A**, **C**) and mean values of only the propulsive phase of the lift (**B**, **D**) are shown.

Sanchez-Medina L et al. Importance of the Propulsive Phase in Strength Assessment. Int J Sports Med 2010; 31: 123–129

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Muscular Power Measurements - 3

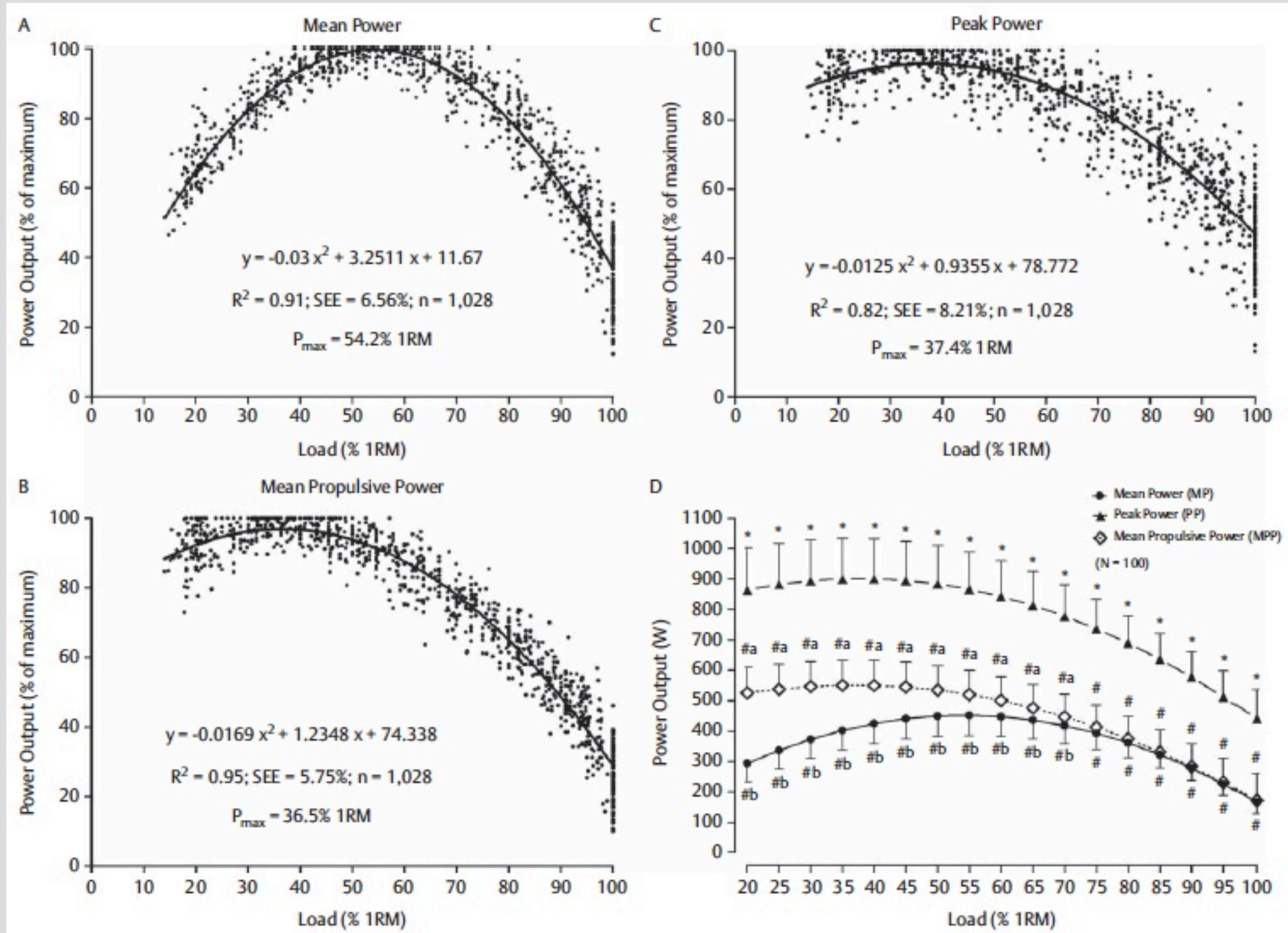


Fig. 4 Load-power relationships according to three different measures of power output in the bench press (**A–C**); and comparison between the absolute power values developed for each condition (**D**) and derived from the second-order polynomial fits to individual load-power data. Significantly different ($p<0.001$) to that obtained using: *MPP and MP; #PP; [a]MP; [b]MPP for each corresponding load.

Sanchez-Medina L et al. Importance of the Propulsive Phase in Strength Assessment. Int J Sports Med 2010; 31: 123–129

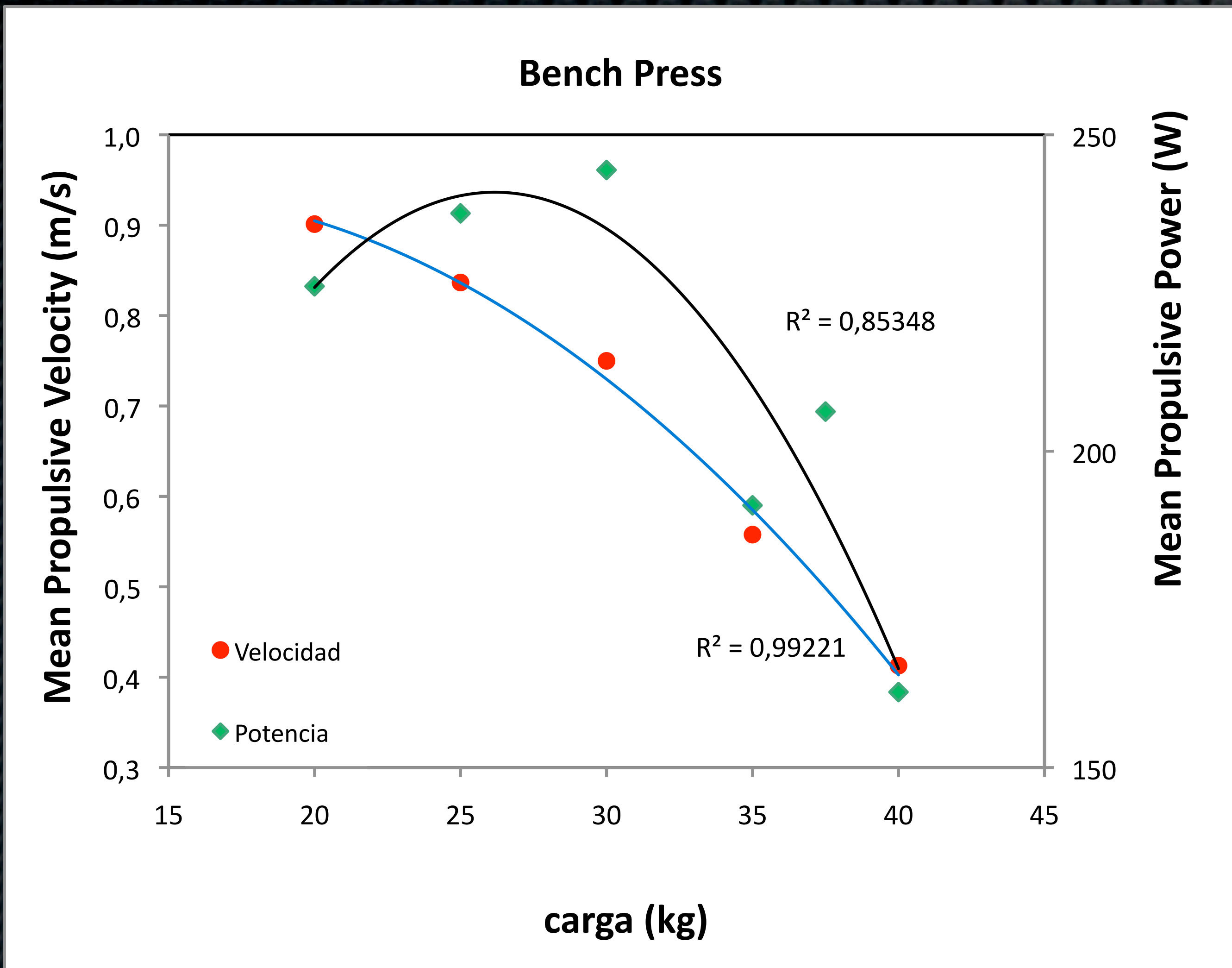
Power Assesment Examples

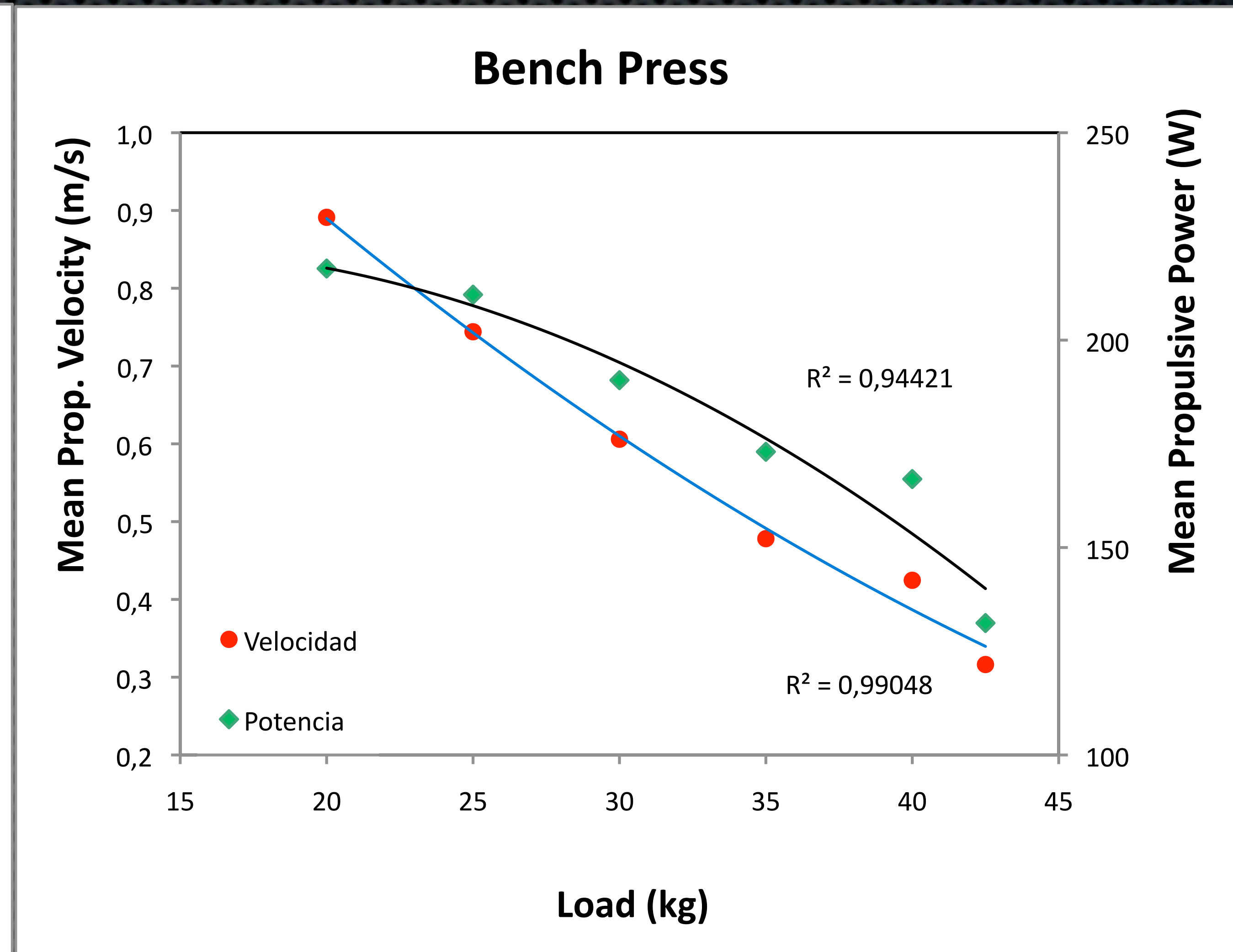
Bench-Pull

Initial Load

Max. Load

Sample: Female Swimmers





Int. Junior 100m -200m

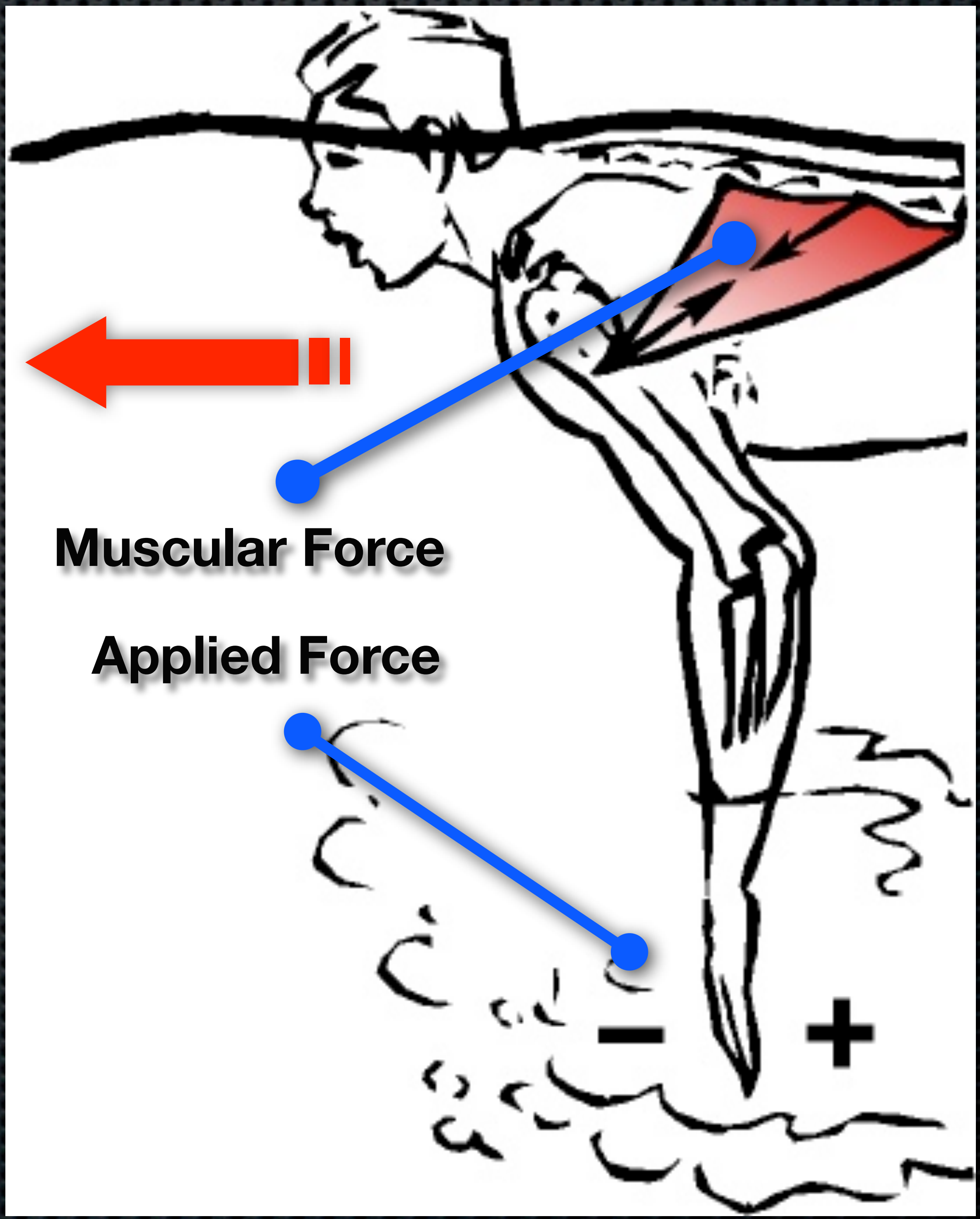
Int. Senior 400m - 800m

Initial Conclusions...

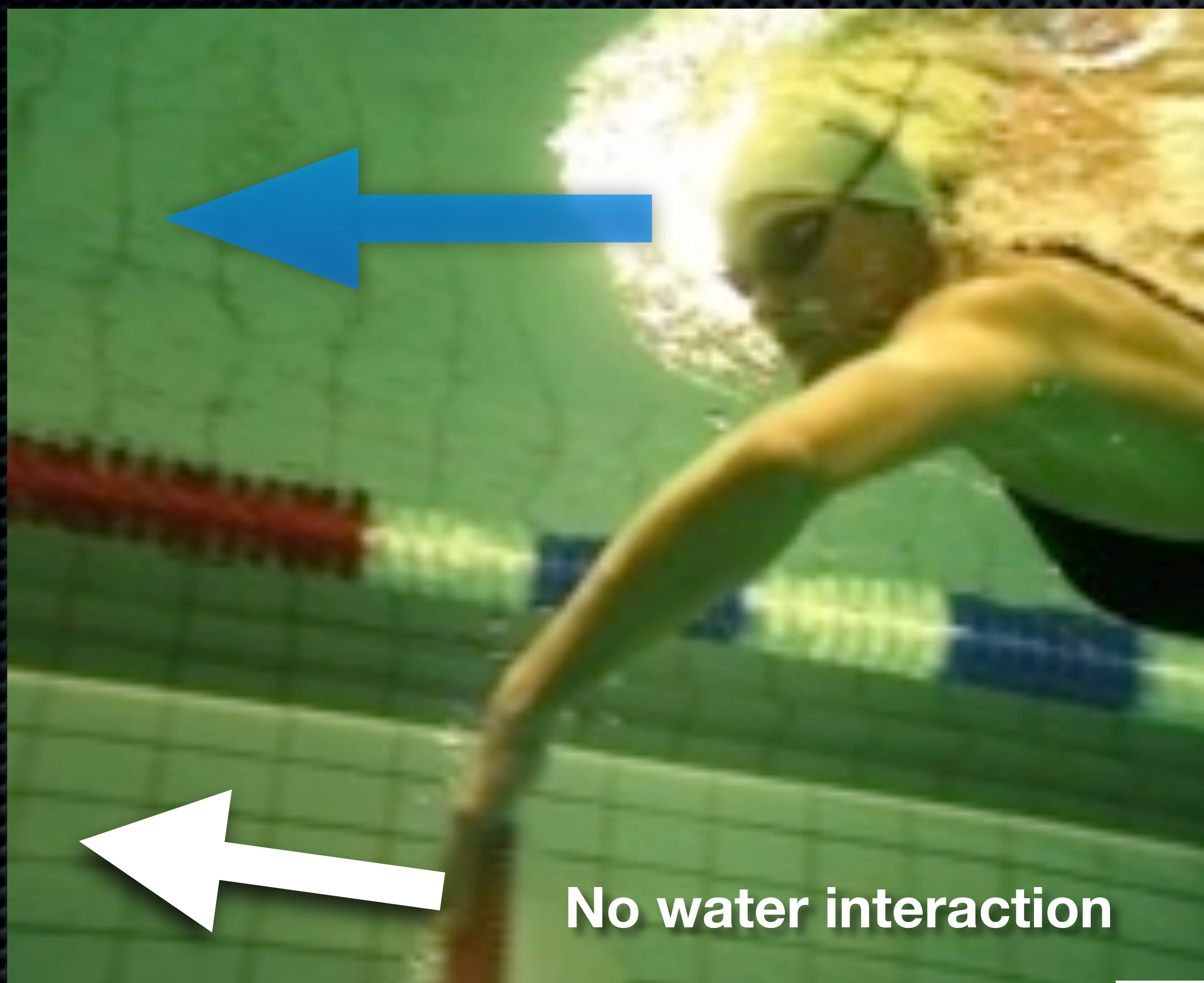
- ➡Lower values of Force and Power were found related to other sports
- ➡The seasonal analysis demonstrates a lack of improvement
- ➡A controlled training is necessary in the near future to improve these results
- ➡Training based on velocity plus load is recommeded

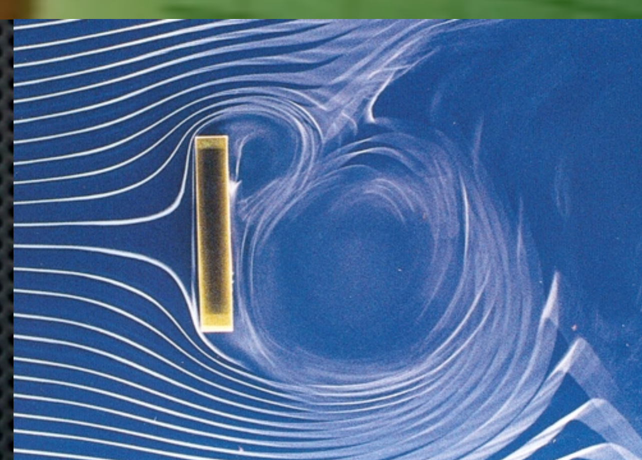
Muscular and Applied Force

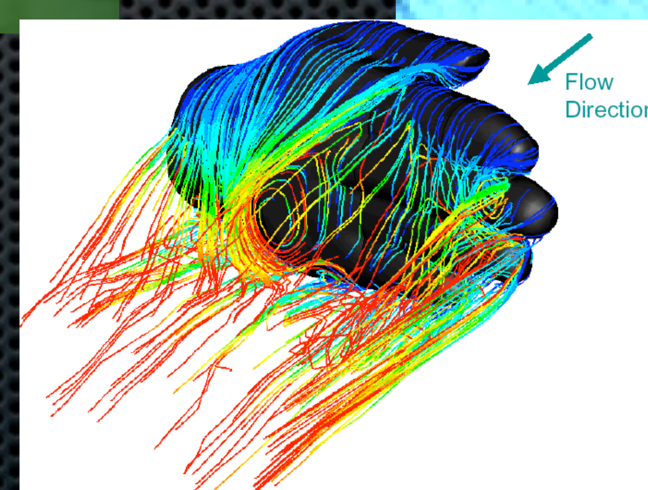
- ➡Propulsive muscle contraction
- ➡Shoulder extension
- ➡The hand movement in the water
- ➡Water interaction with hand / limb



Muscular and Applied Force II







Very complex
water interaction

Leg propulsion and wake interaction

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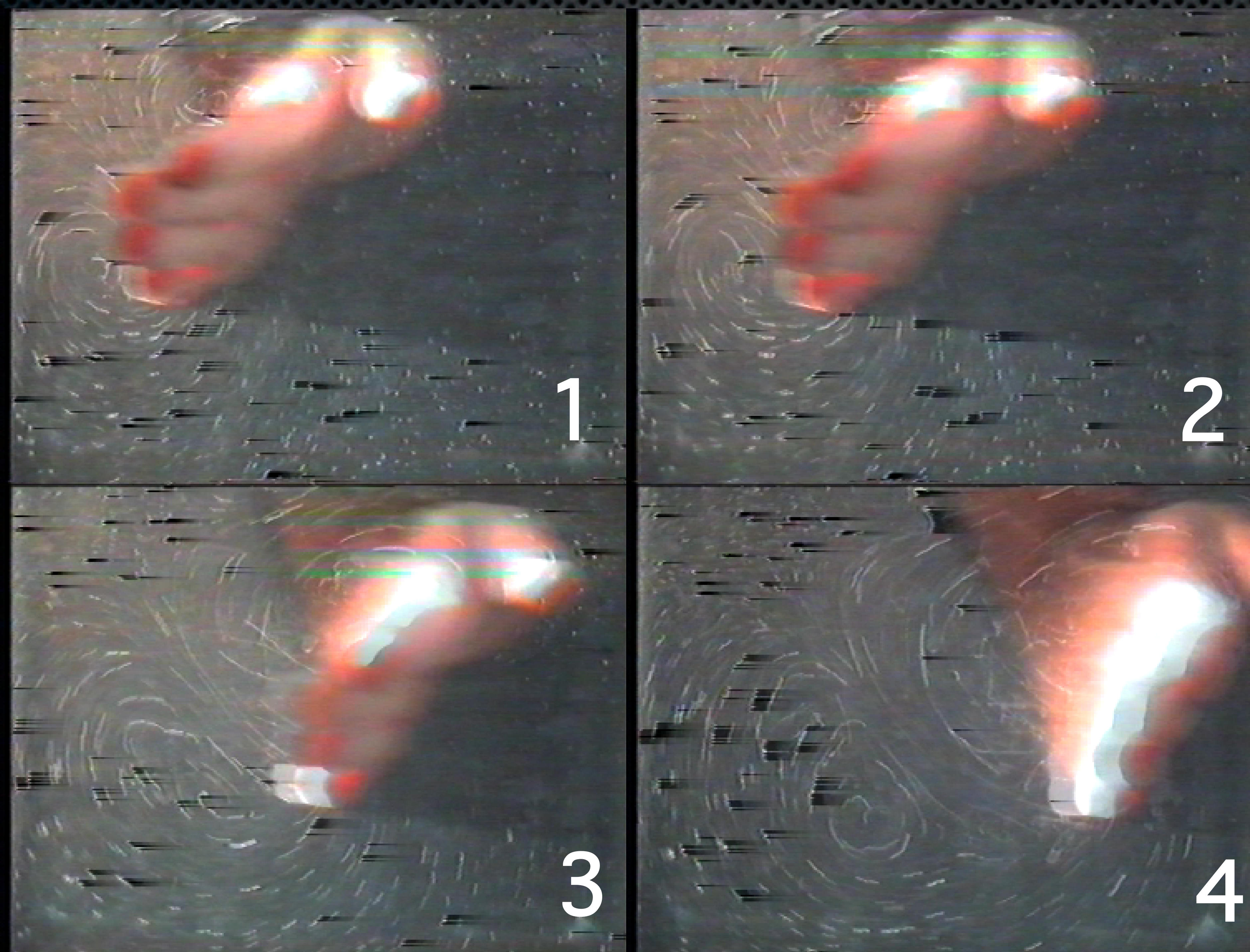
Trajectories of the sheeded particles in an experimental tank while a hand stroke is performed.



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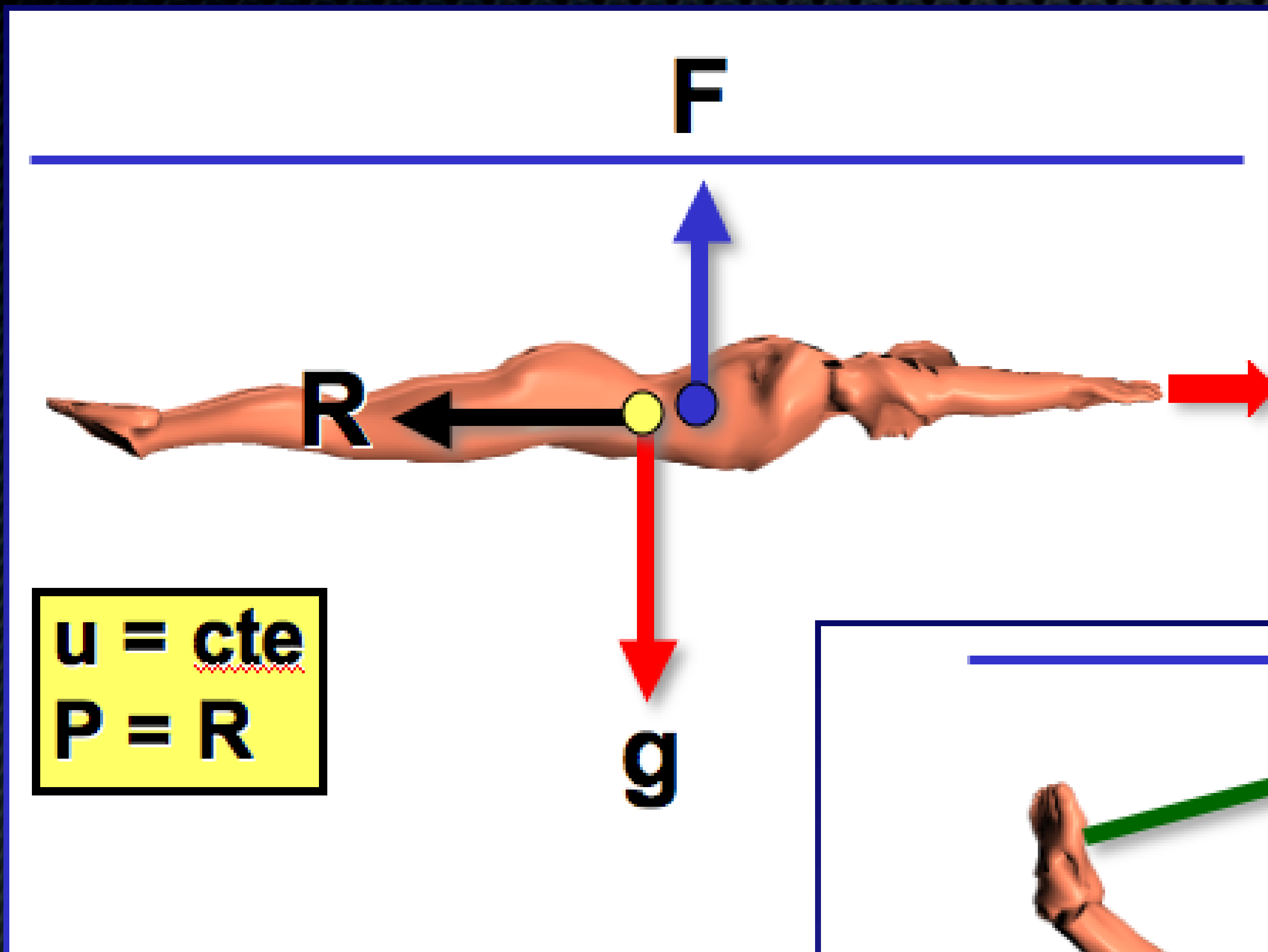
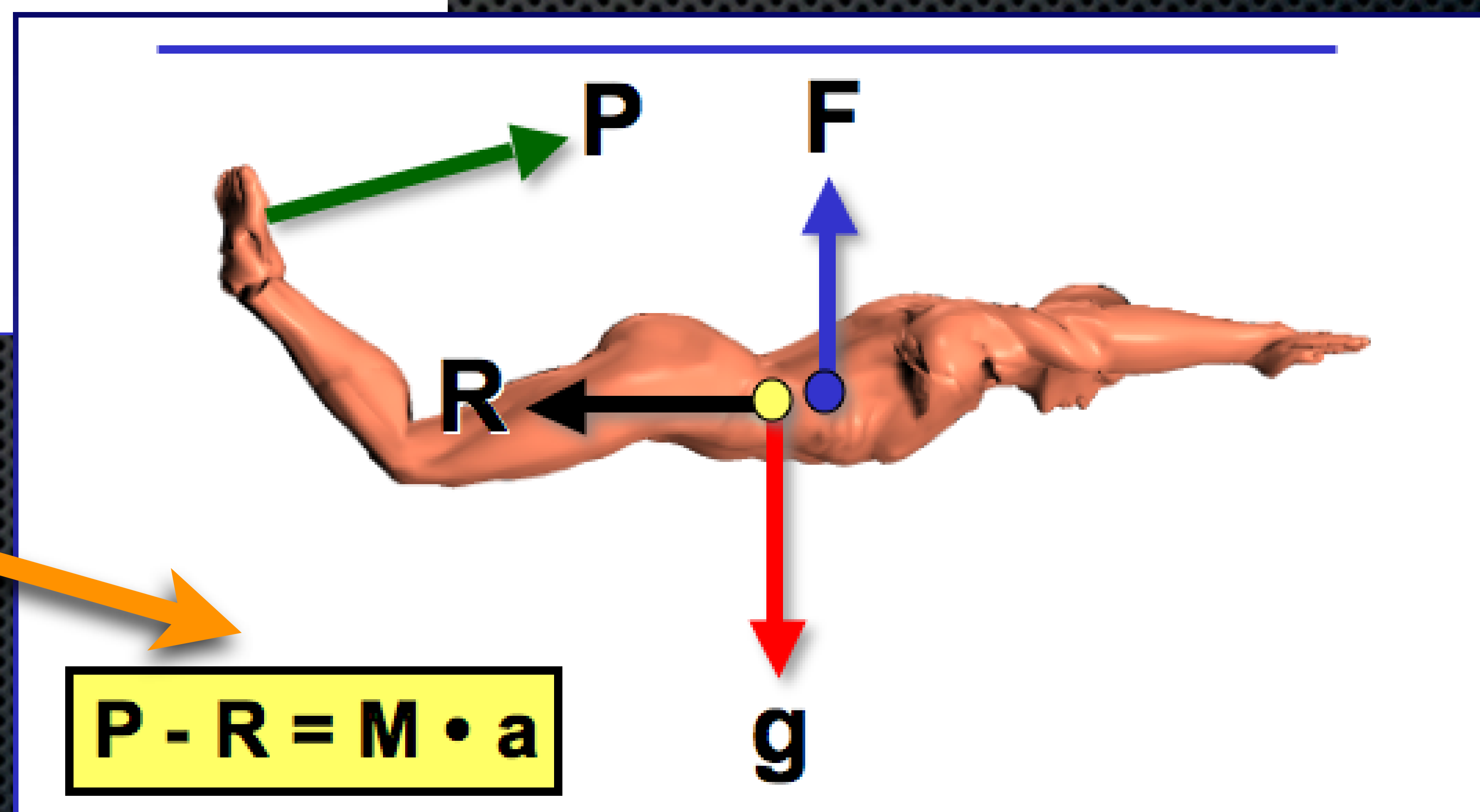
External Forces



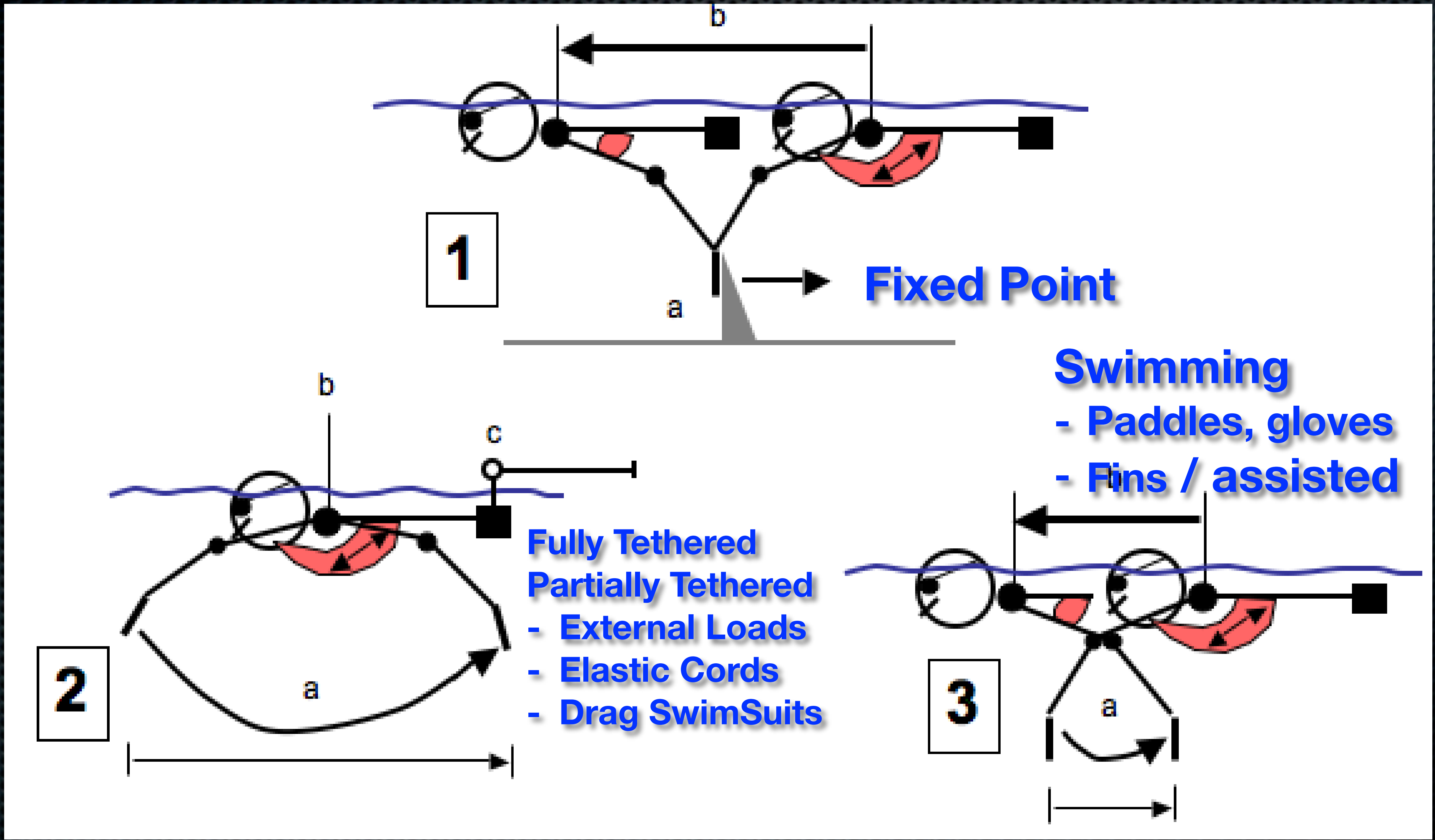
Constant Velocity

Self-propulsion



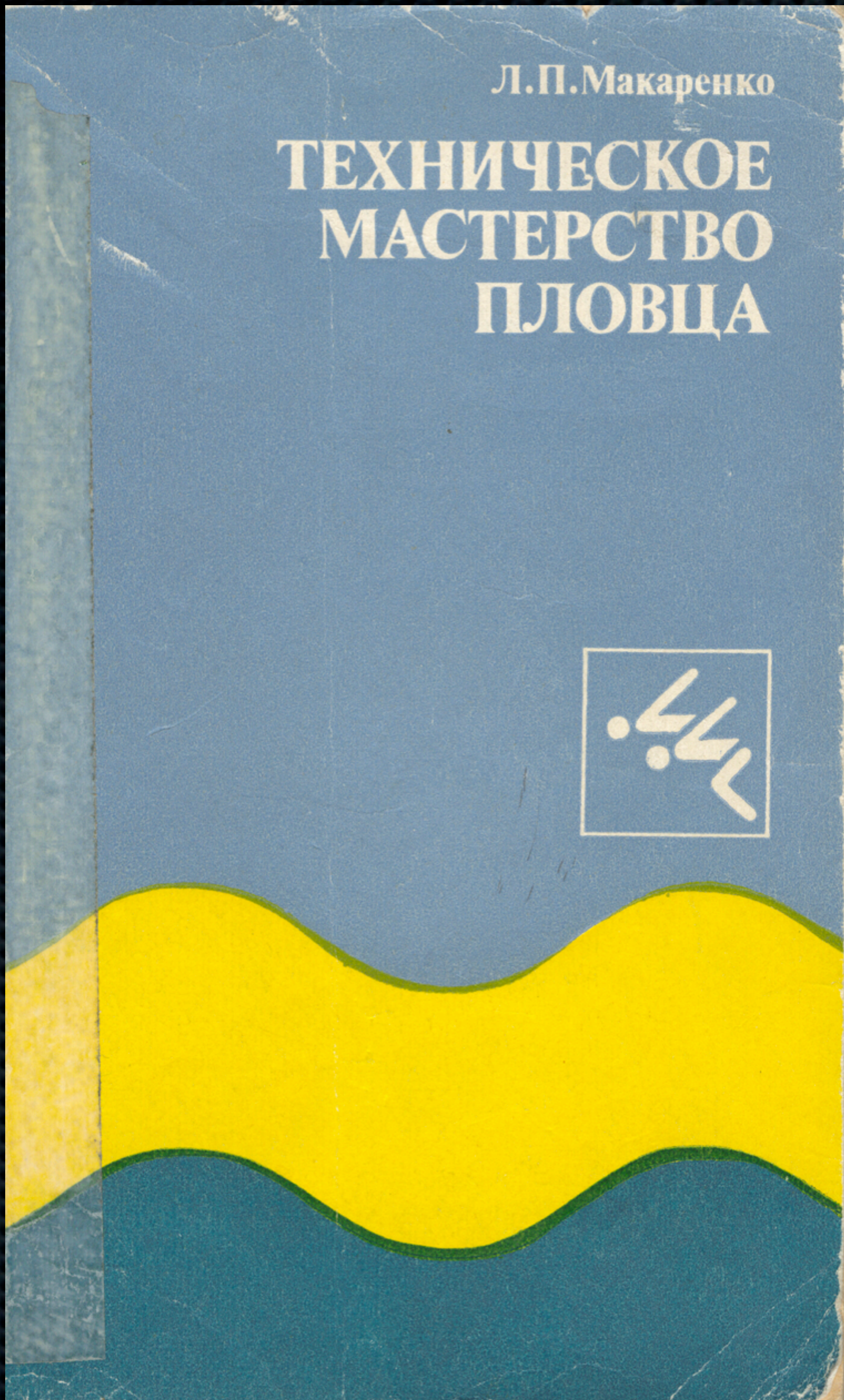
$P = M\,a + R$

Some types of propulsion and variations



➡All bodies (including propulsive limbs) displacing water will create vortices (rotating water masses) in their wakes; they carry a fairly high momentum, which can transfer a strong propulsive impulse to the body (Ungerechts, 2003).

Makarenko, 1975



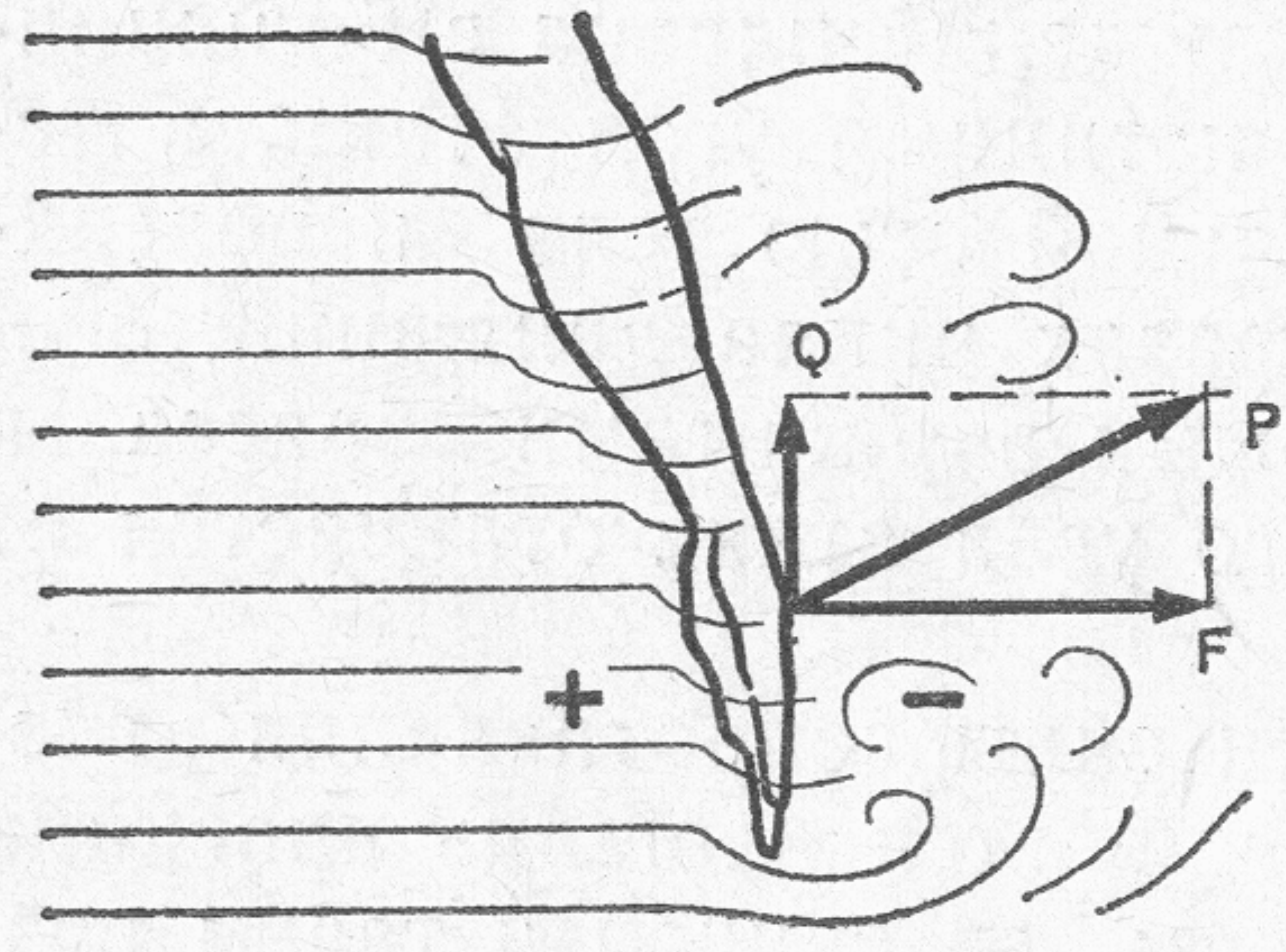
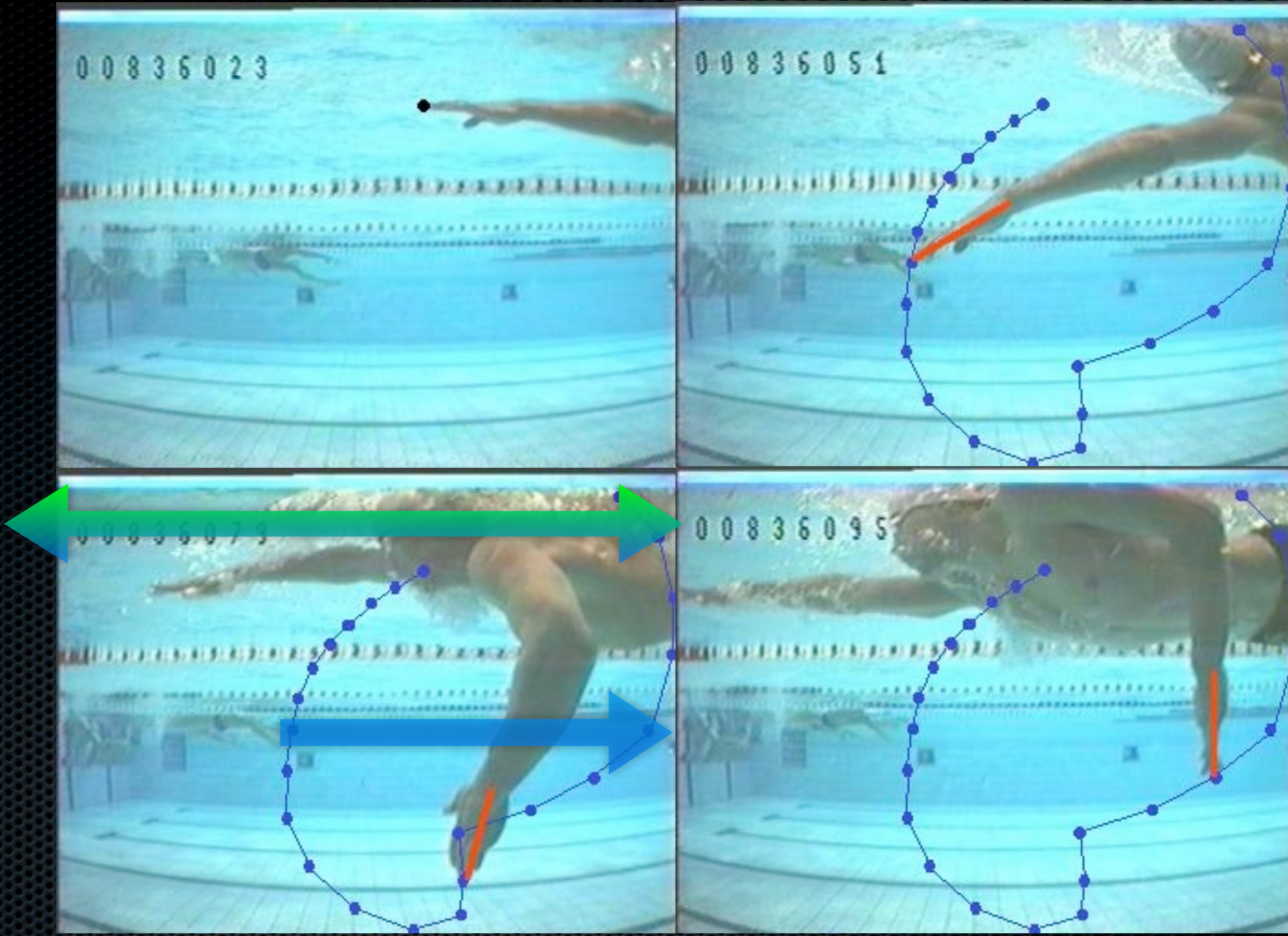


Рис. 6. Сила опорной реакции



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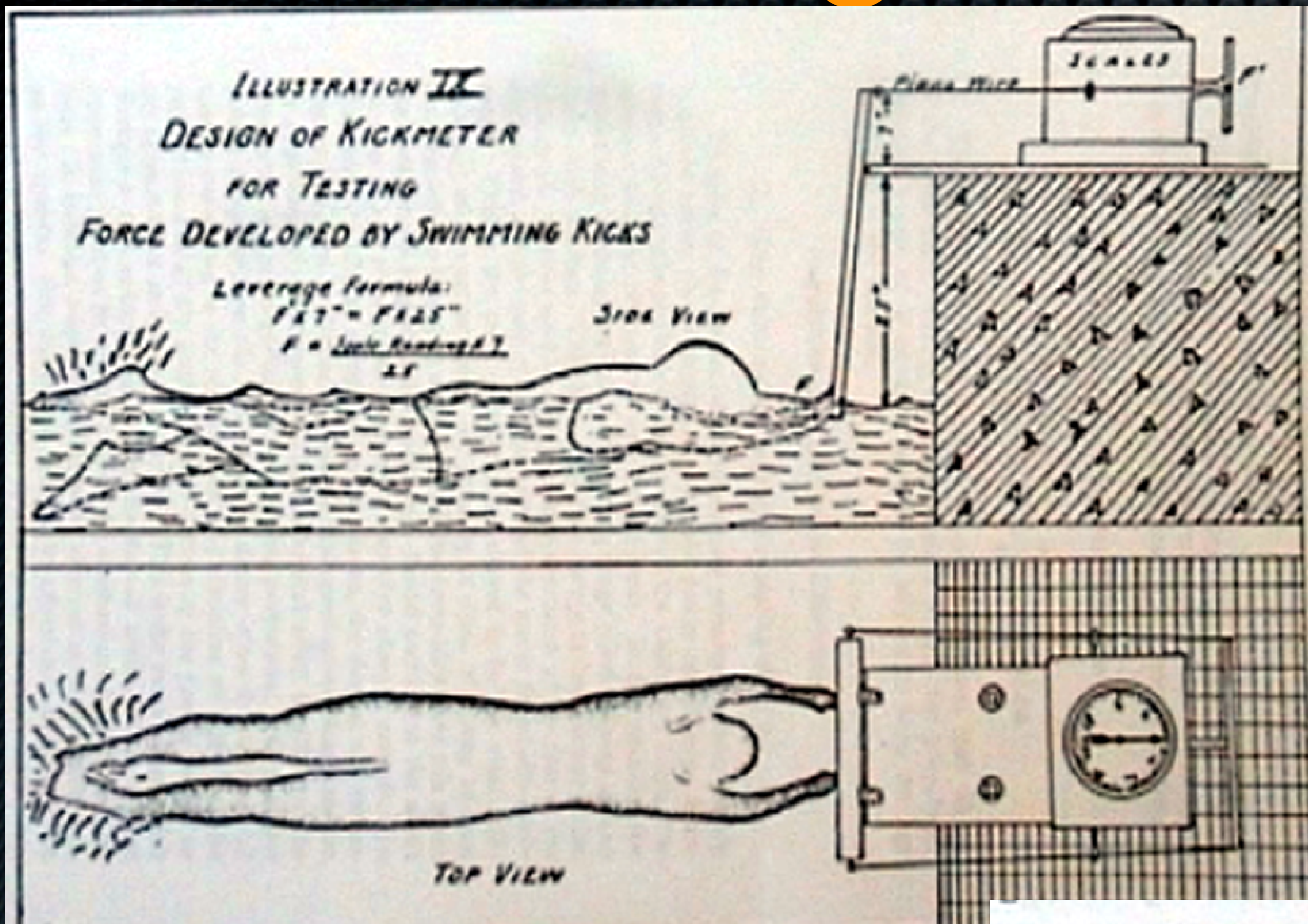
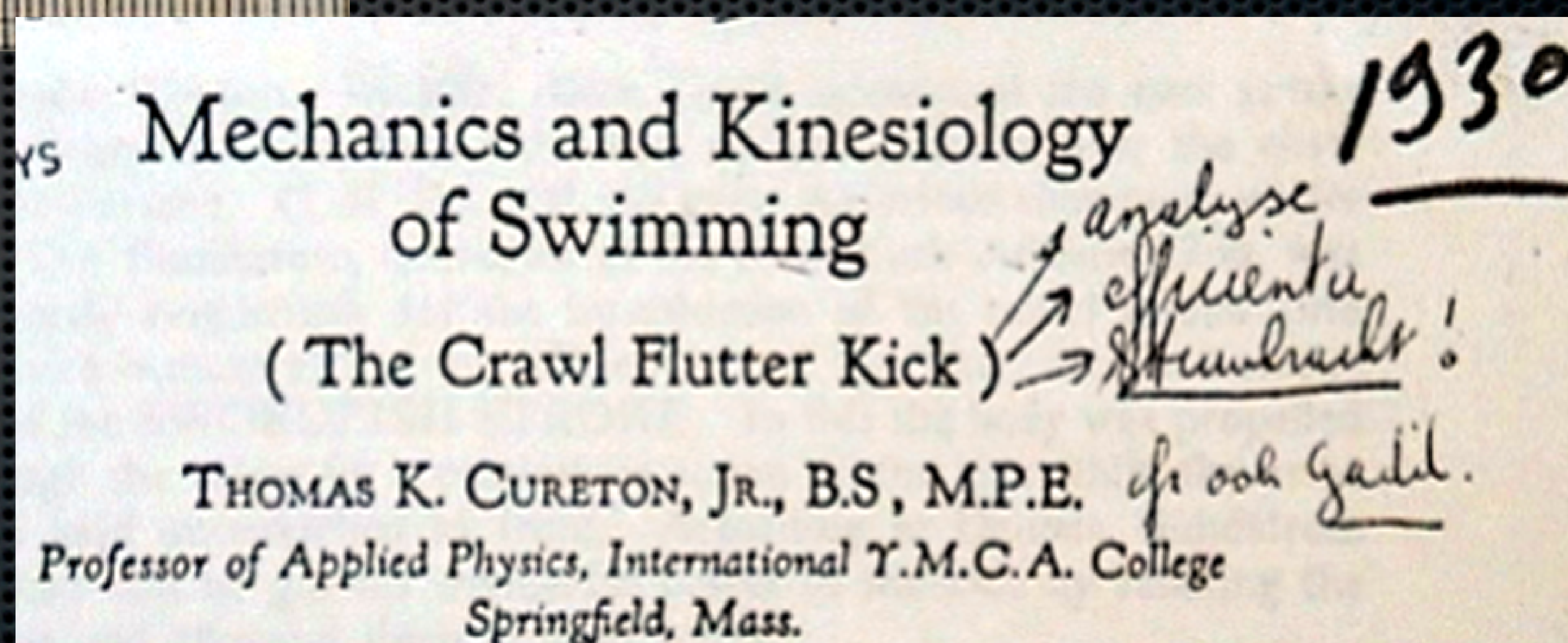
Measuring Swimming Force...

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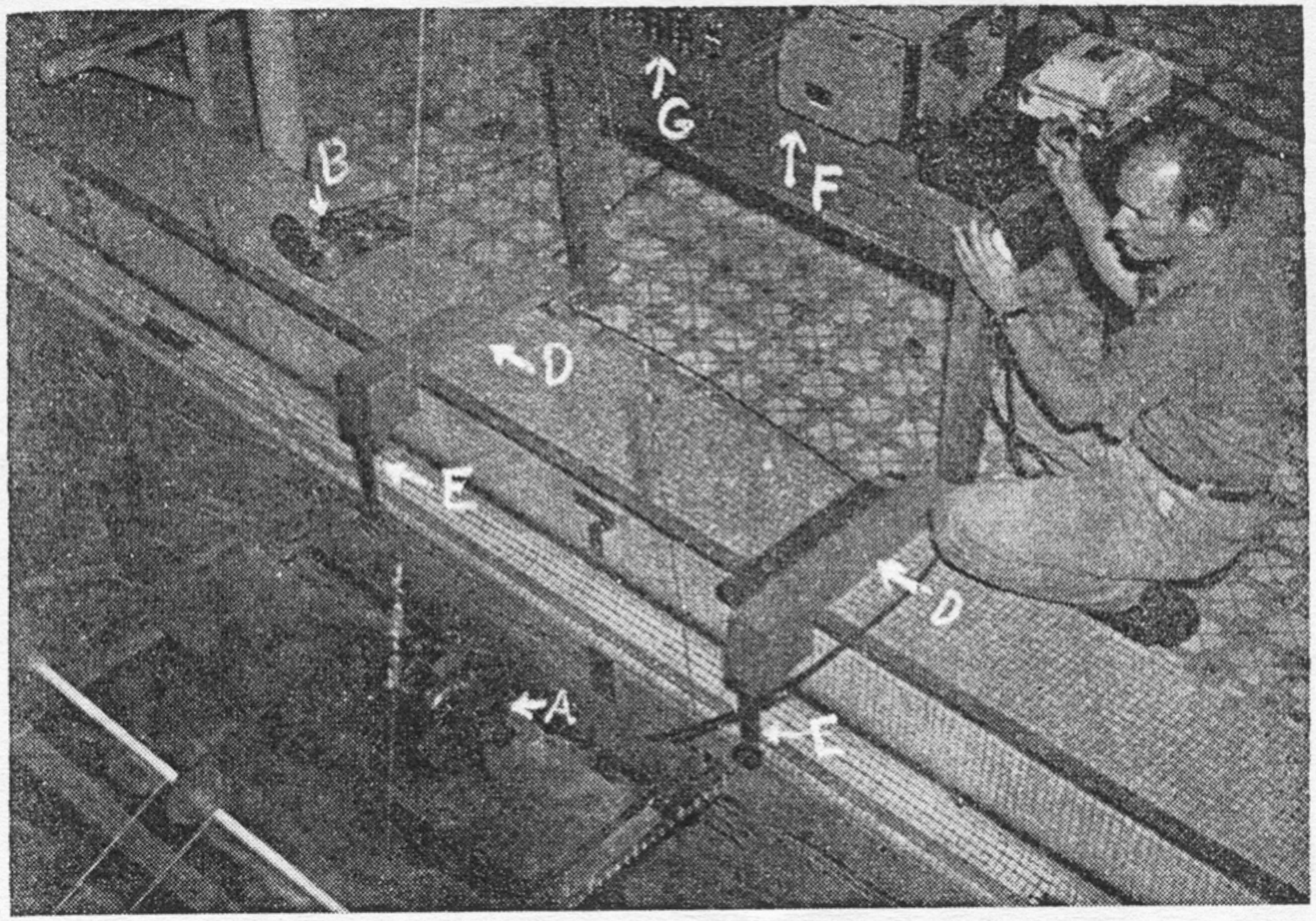
Mechanics and Kinesiology
of Swimming

(The Crawl Flutter Kick)

THOMAS K. CURETON, JR., B.S, M.P.E.

Professor of Applied Physics, International Y.M.C.A. College
Springfield, Mass.

Forces in Two Types of Crawl Stroke 129



IGURE I. Towing Apparatus, Measuring Device, and Pacing Device. *Key:* A. Motor; . Placing device; C. Step pulley; D. Iron clamps; E. Steel beams; F. MRC Strain Gage Control Unit; and G. Hathaway S14-C Galvanometer.

Forces in Swimming Two Types of Crawl Stroke

JAMES E. COUNSILMAN
Cortland State Teachers College
Cortland, New York

Power Delivered to Ext. W.

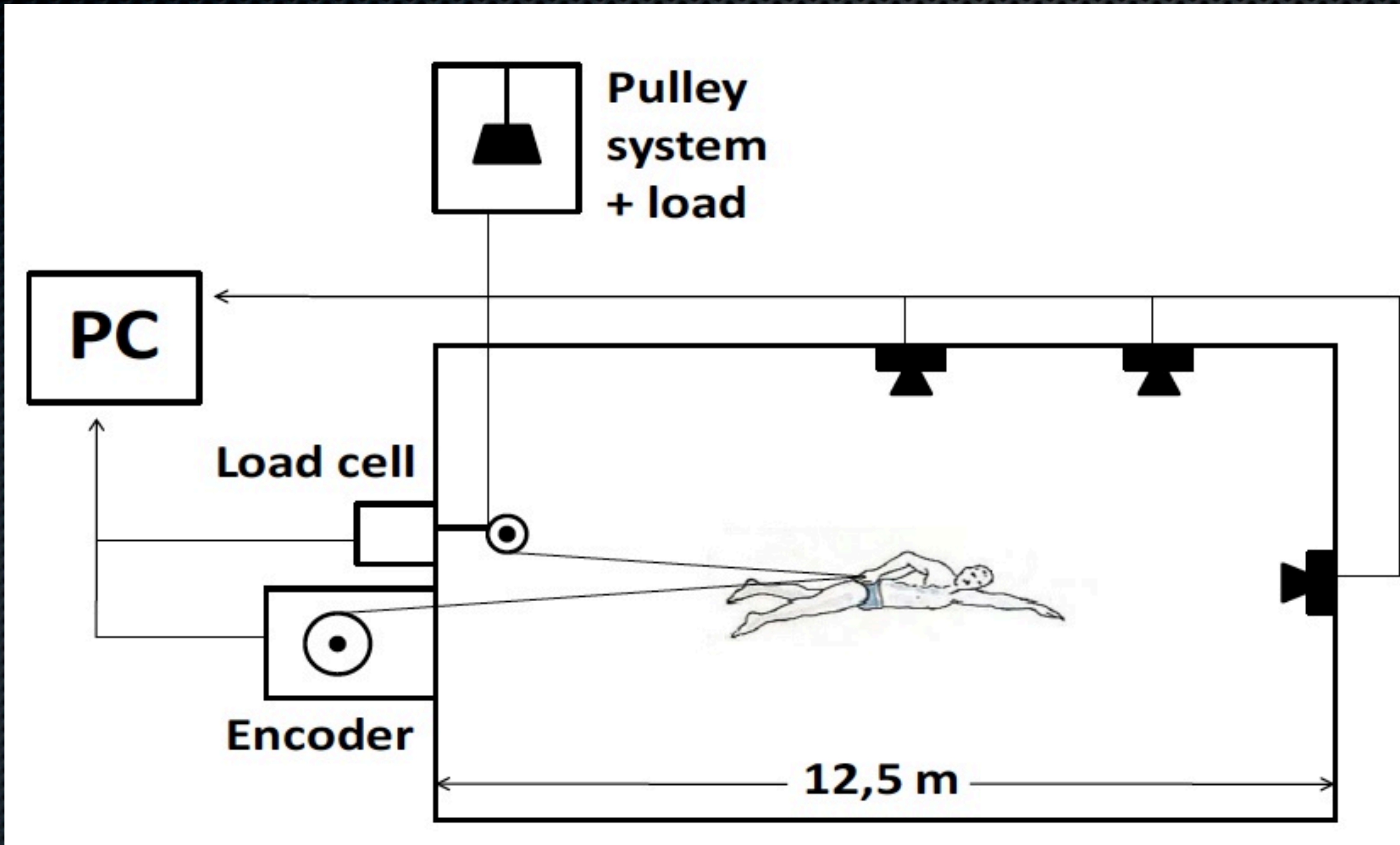
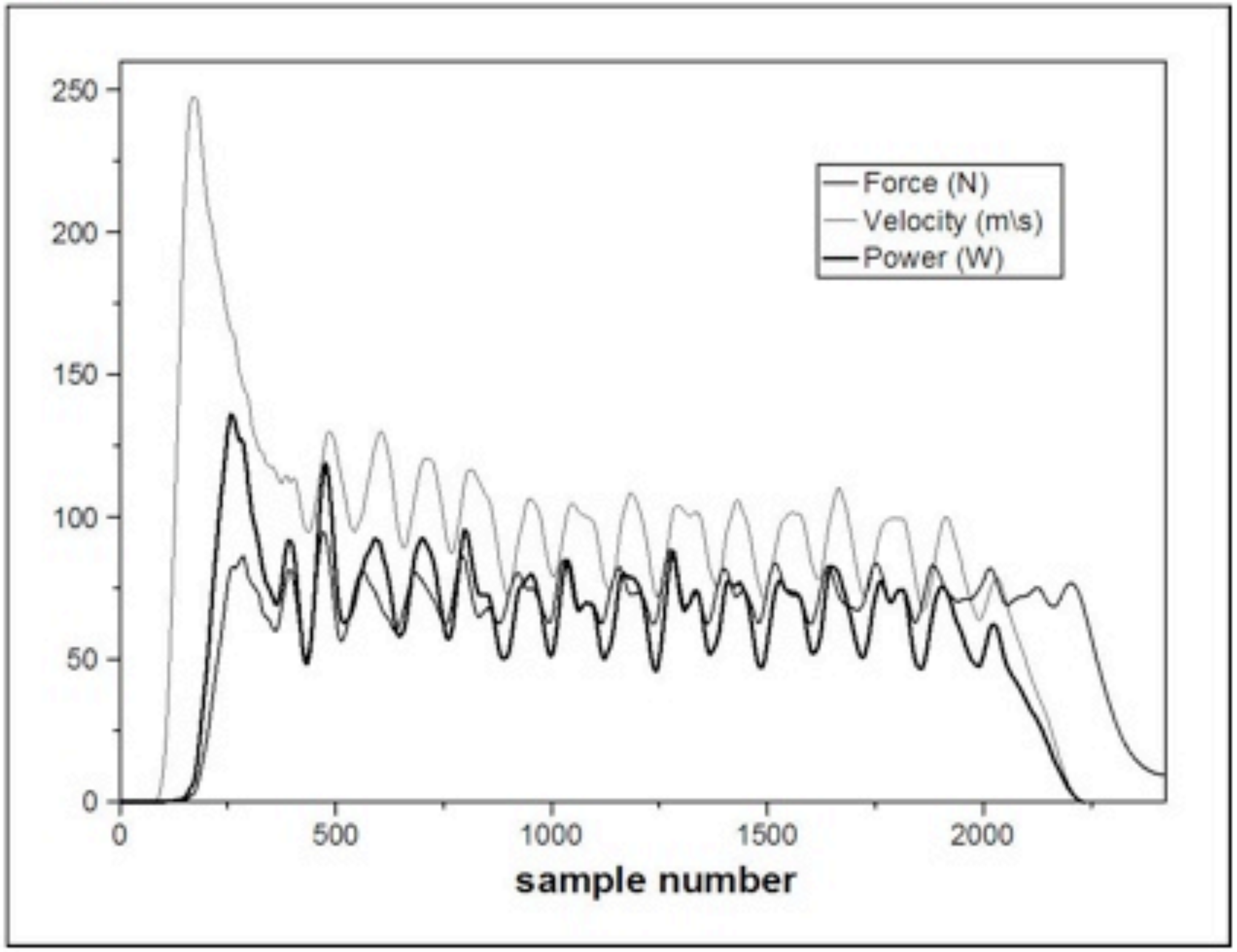
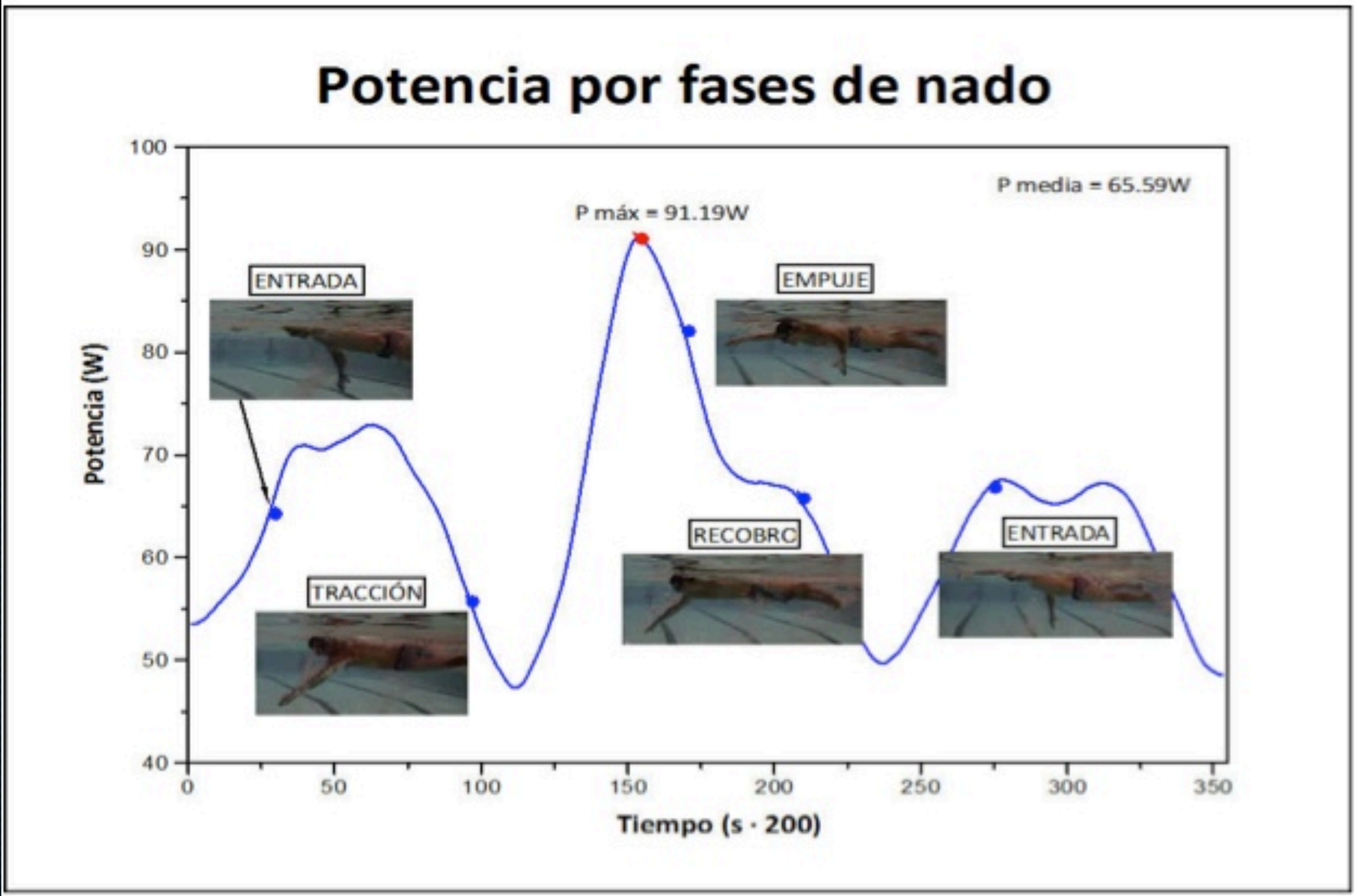


Figure 1



En esta figura hay que poner las unidades en el eje Y (watios y Newtons) que son las que tienen rangos parecidos en la izquierda y la velocidad a la derecha (Y secundario). En la parte de abajo en vez de "samples number" debes poner "Time (s)" y ajustar el eje a esta información.

Figure 2



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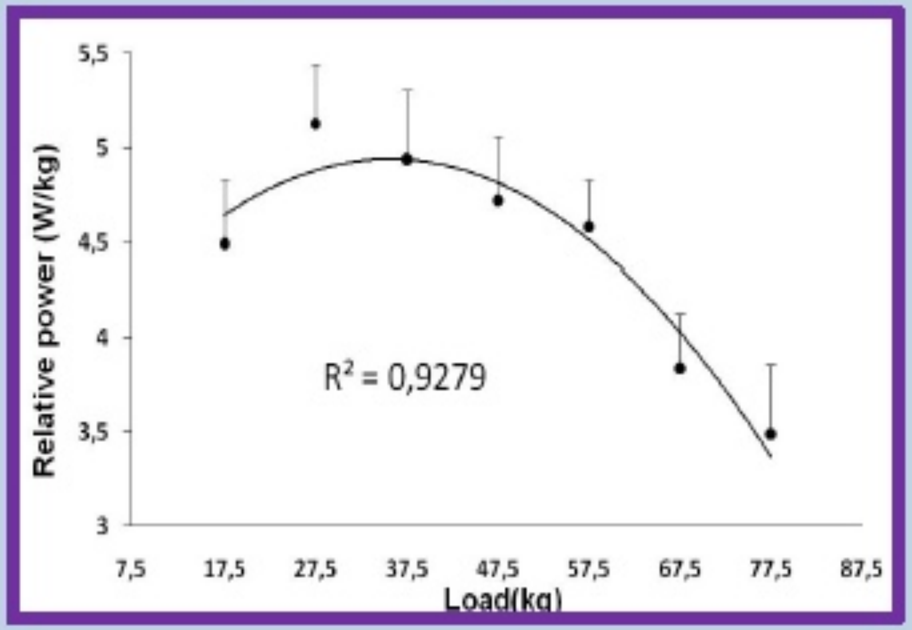
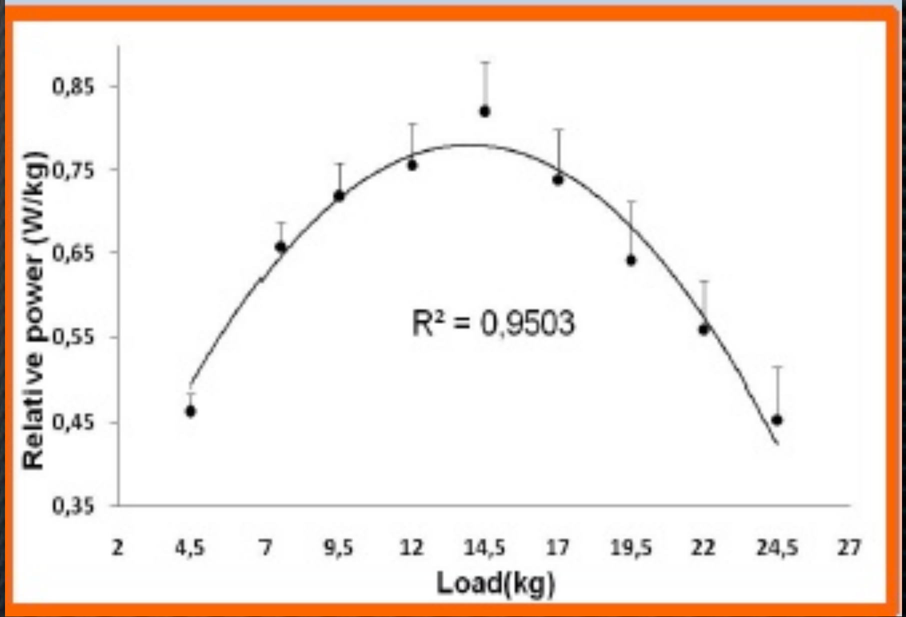
Some Results...

	max BPP (W)	max BPP (W/kg)	% RM-max BPP	v[1]-max BPP (m/s)	max SP (W)	max SP (W/kg)	% max load-max SP[2]	v-max SP[3] (m/s)	%v max-max SP
MEAN	418.18	5.41	41.32	1.04	66.49	0.86	47.07	0.75	43.75
SD	134.53	1.47	14.64	0.26	19.09	0.21	9.45	0.18	8.94

Bench press power curve



) Swim power curve.



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Other previous results

Table 2. Maximal swimming power calculated in other studies.

Swimming power (66.49W or 0.86W/kg)*	
Authors	SP values
Costill et al. (1986)	55W or 0.656W/kg
Saijoh et al. (2008)	85.7W
Shimonagata, et al. (2002)	100.71W
Shionoya et al. (1999)	51.20W
Toussaint et al. (2004)	97.3W^
Toussaint et al. (2006a)	200W+
Toussaint et al. (2006b)	220W+

Propulsion equation

➡Accelerating a body in a fluid involves a force with additive components:

- The old friend DRAG
- The force needed to accelerate the mass of the body forward

Propulsion equation

Drag of Swimmer's Body

$$F = \frac{1}{2} C_d \rho S U^2 + ma + C_a \rho V a$$

Added mass coefficient

VIRTUAL MASS

Acceleration-reaction force

Propulsion equation

Drag of Swimmer's Body

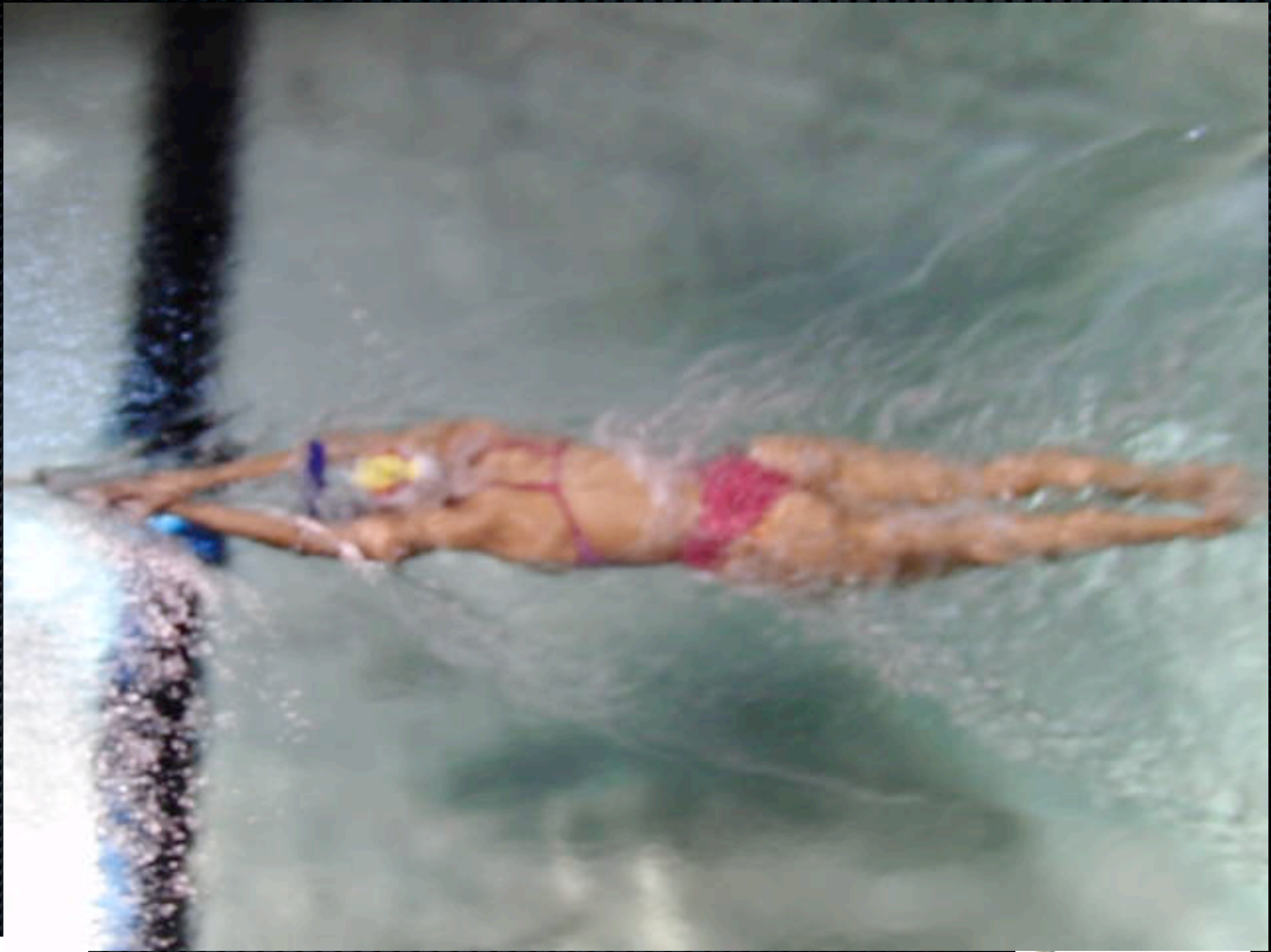
Added mass coefficient

Added Mass
23.6 - 26.8%

$$F = \frac{1}{2} C_d \rho S U^2 + ma + C_a \rho V a$$

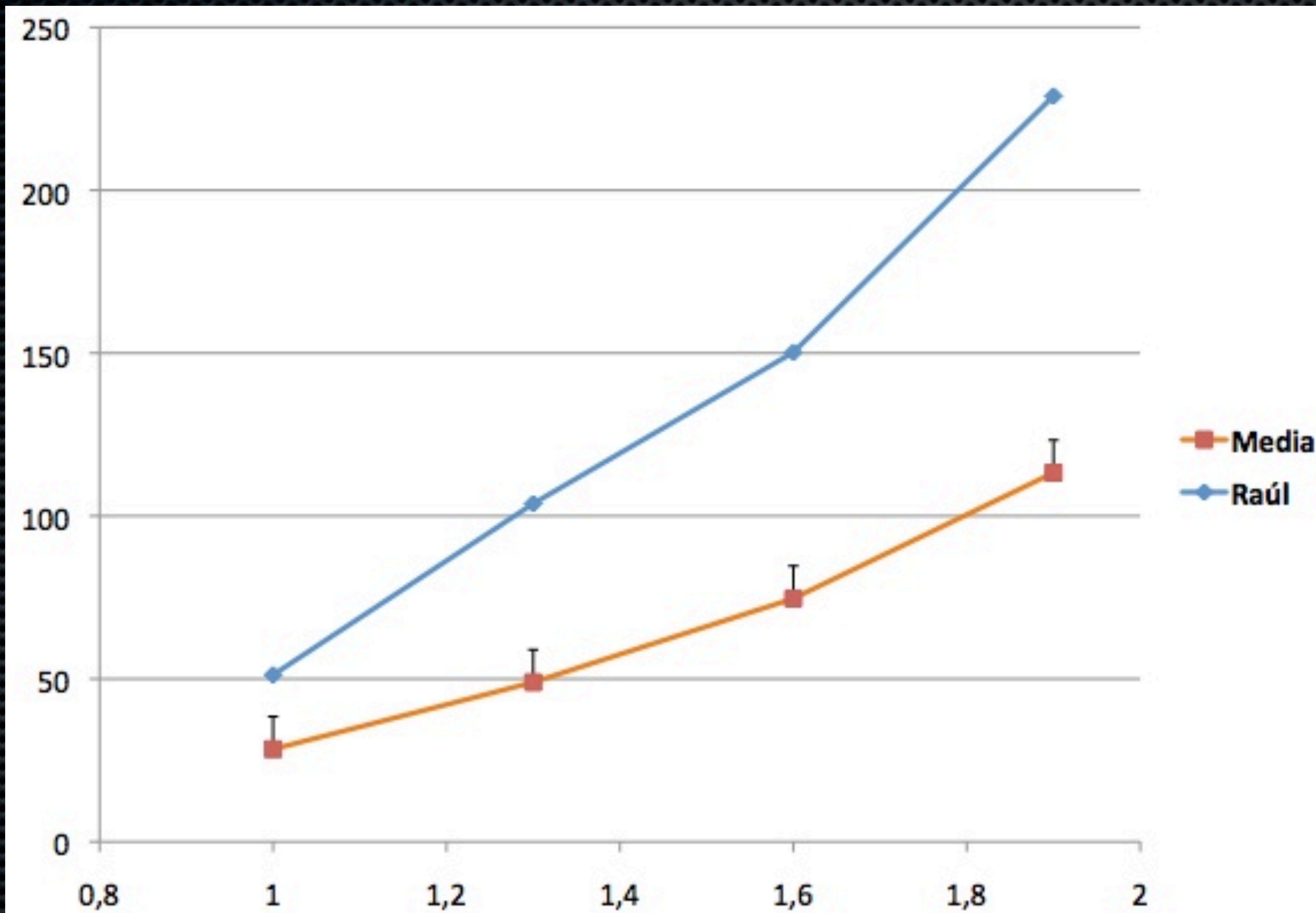
VIRTUAL MASS

Acceleration-reaction force



Passive Drag

Drag (N)



Water Velocity (m/s)

Propulsion equation

Drag of Swimmer's Body

Added mass coefficient

$$F = \frac{1}{2} C_d \rho S U^2 + ma + C_a \rho V a$$

VIRTUAL MASS

Acceleration-reaction force

Propulsion equation

Drag of Swimmer's Body

$$F = \frac{1}{2} C_d \rho S U^2 + ma + C_a \rho V a$$

Added mass coefficient

VIRTUAL MASS

Acceleration-reaction force

Added Mass 23.6 - 26.8%

Acknowledgments

- ➡This research is funded by Ministry of Science and Innovation (Spain) - [AP2008-03243]
- ➡Blanca de la Fuente.
  - Biomechanics Lab. Altitud Training Centre of Sierra Nevada. Granada. Spain.
- ➡ Physical Activity and Sport in the Aquatic Environment” (CTS 527) and Physical Education Department for providing all the necessary equipment and the Faculty of Physical Activity and Sport Sciences of University of Granada for allowing the use of the swimming pool and the gym

Thank you for your attention

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