Sports and Physics

Ljubljana, 22. 1. 2010

Leopold Mathelitsch
Institut für Physik
Physikdidaktikzentrum Graz
Universität Graz

Sports und Physics

interdisciplinary

motivation

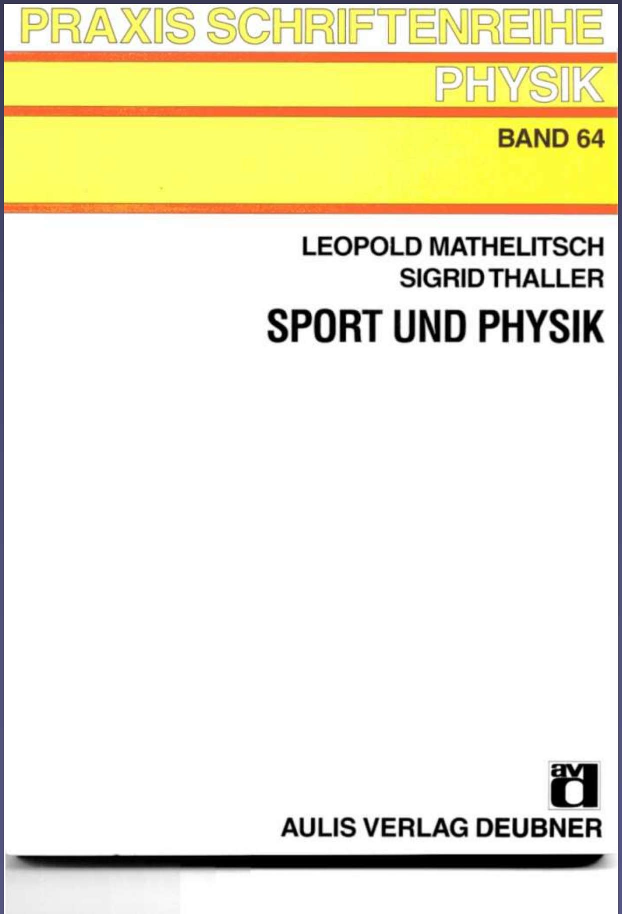
activity - experiments

multimedia

Sport und Physik

S. Thaller
Inst f. Sportwissenschaften, Univ. Graz

Th. Duenbostl, Th. Oudin
BG/BRG Ettenreichgasse, Wien


PRAXIS SCHRIFTENREIHE
PHYSIK
BAND 64
LEOPOLD MATHELITSCH
SIGRID THALLER
SPORT UND PHYSIK
AULIS VERLAG DEUBNER

Sports and Physics

High Jump

Carving

Shot Put

Basquet Ball

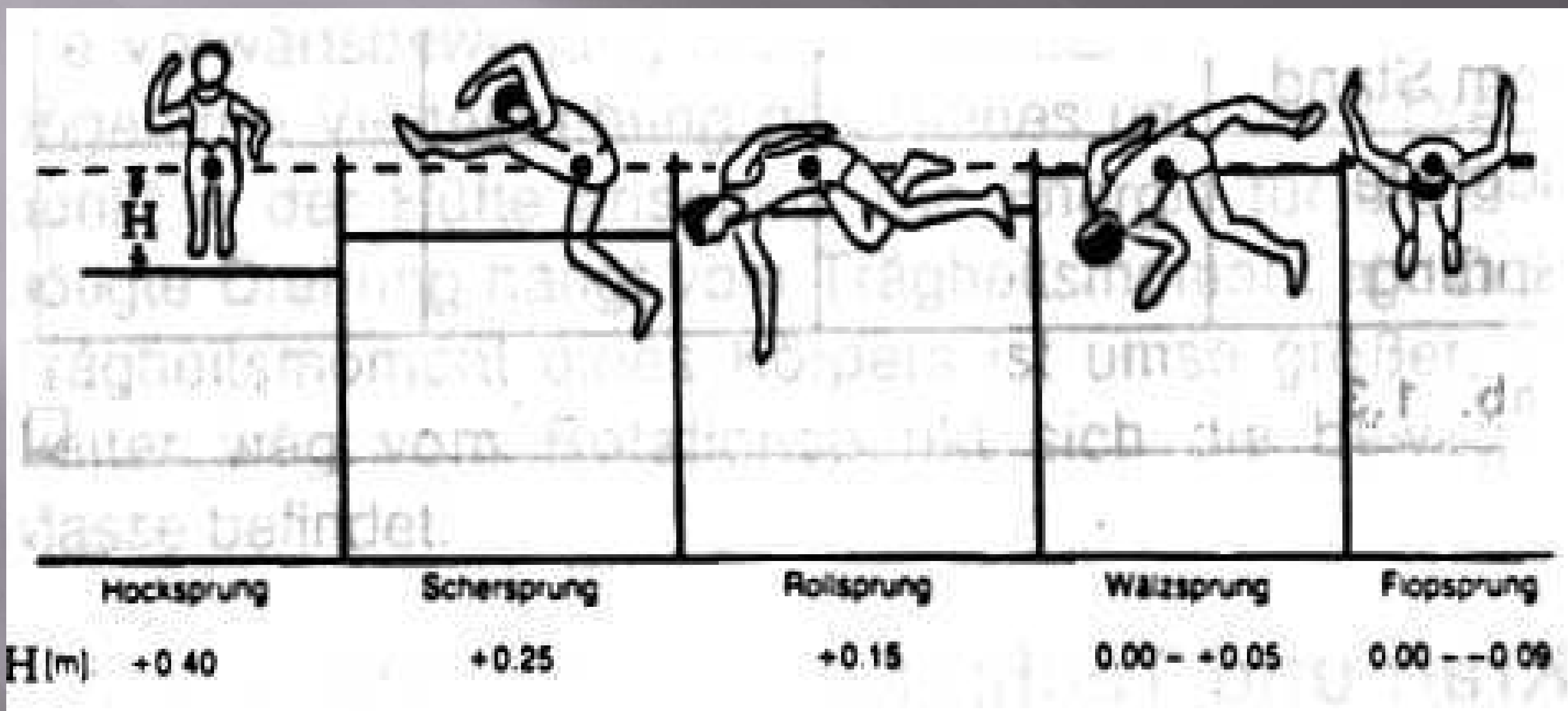
Billard

Tennis

Soccer

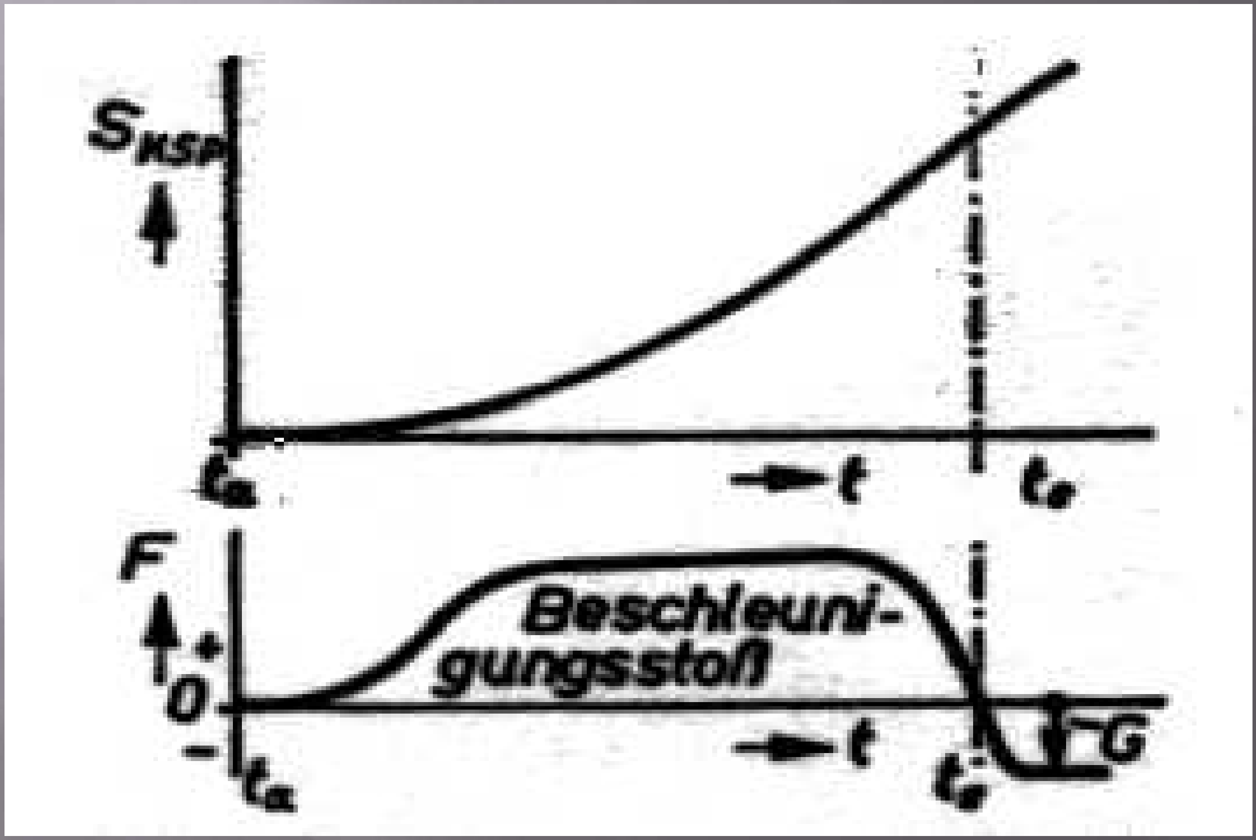
High jump

High jump



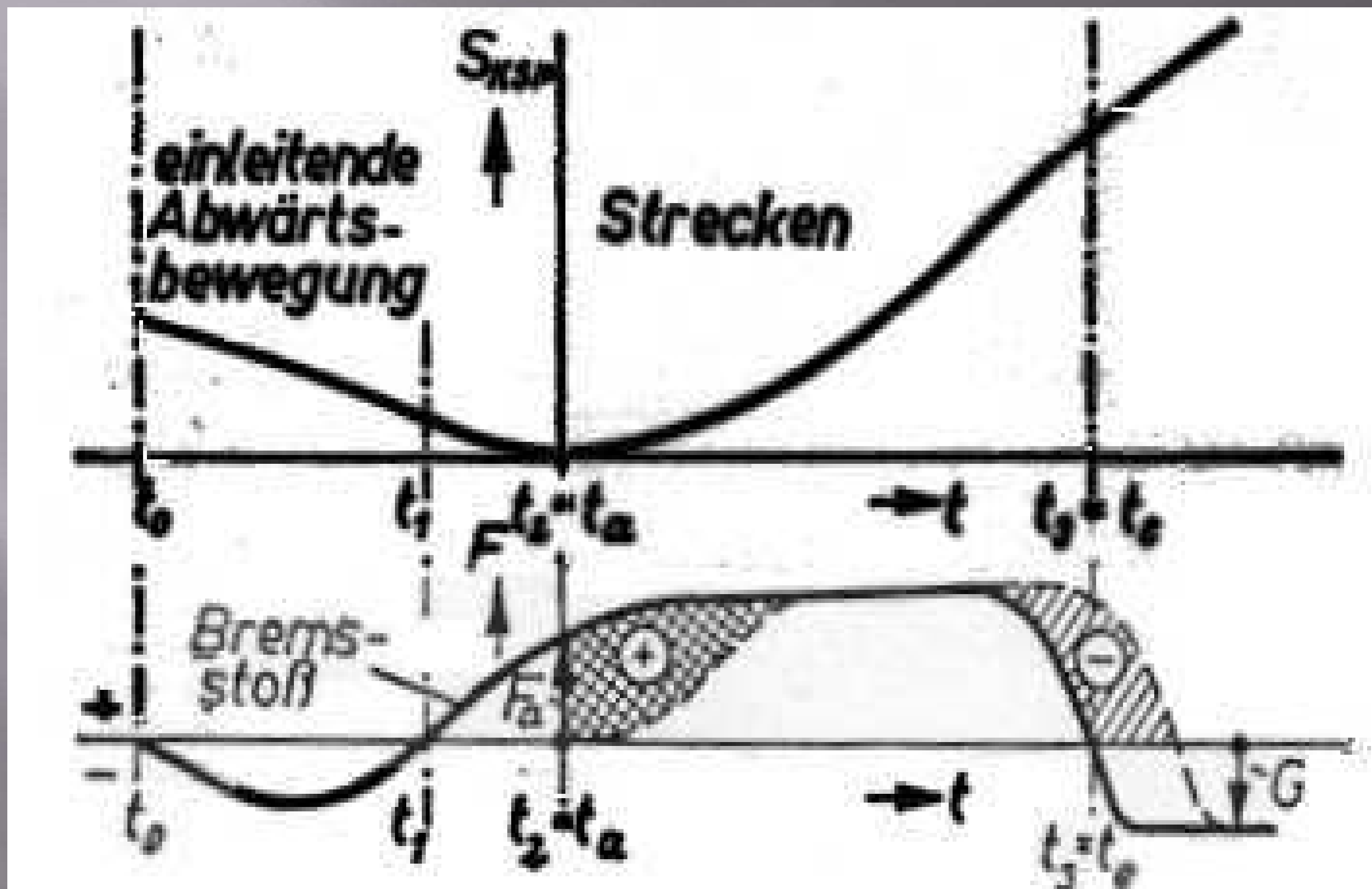
H
Hocksprung
Schersprung
Rollsprung
Wälzsprung
Flopsprung
H (m) +0.40
+0.25
+0.15
0.00 – +0.05
0.00 – -0.09

Jump from rest

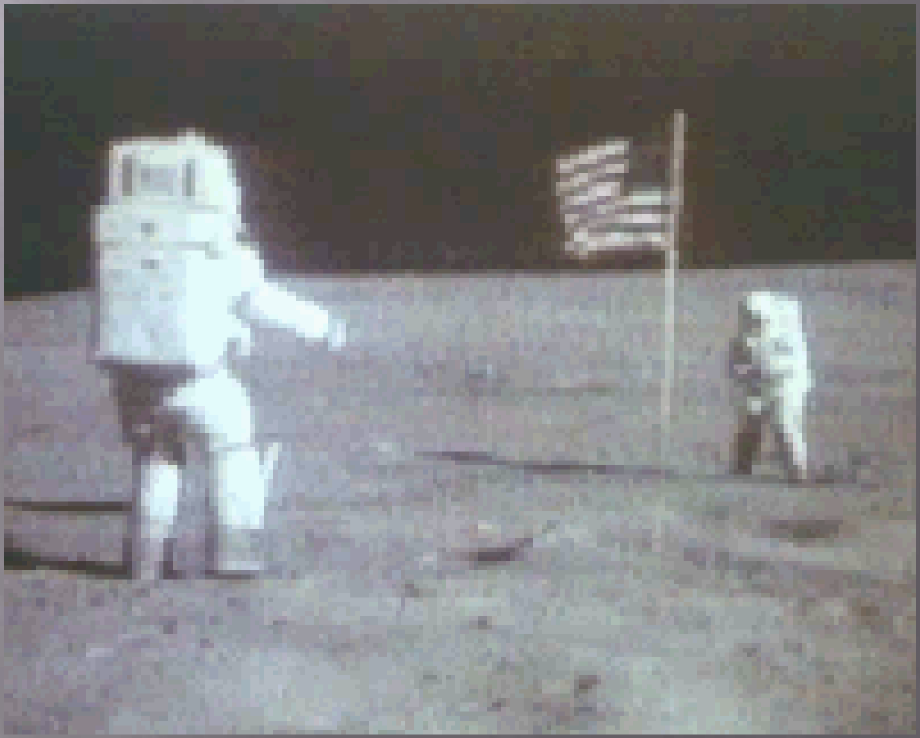


aus G. Hochmuth „Biomechanik der Sportarten“

Initial force



John Young, Apollo 16, April 20, 1972



Models

1. Same speed
2. Same force
3. Models
4. Individual differences

1. Same speed

Conservation of energy

Kinetic energy + potential energy = const.

$$\frac{1}{2} m \cdot v_{Ab}^{\ 2} + m \cdot g \cdot h_{Ab} = m \cdot g \cdot (h_{Ab} + h)$$

$$h = \frac{v_{Ab}^{\ 2}}{2g}$$

$$\boxed{\mathbf{h_{Mond} = 6\ h_{Erde}}}$$

2. Same force

The force, which the muscle exerts on the ground, is constant and independent of gravitation.

$$m \cdot a = F - m \cdot g \quad = F_1$$

Constant force

$$\boxed{m\cdot a = F - m\cdot g \;= F_1}$$

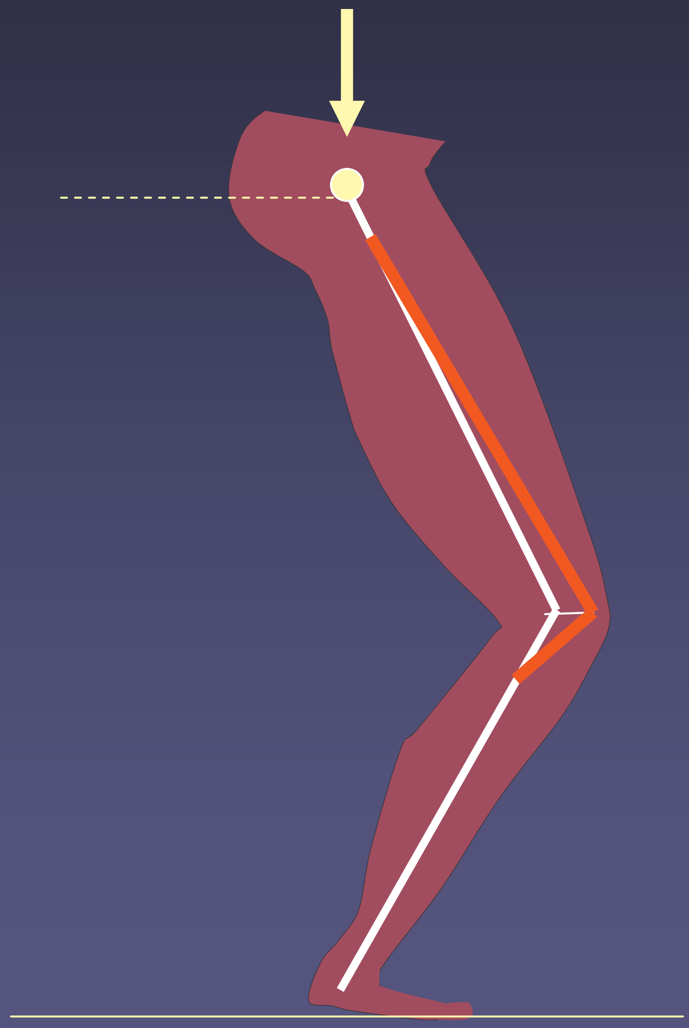
$$F = 2\cdot m\cdot g \longrightarrow F_1^{Erde} = m\cdot g \qquad F_1^{Mond} = \tfrac{11}{6}\cdot m\cdot g$$

$$t_{Ab} = \sqrt{\frac{2(s_{Ab} - s_0).m}{F_1}} \longrightarrow t_{Ab}^{Mond} = \sqrt{\frac{6}{11}}\cdot t_{Ab}^{Erde}$$

$$v_{Ab} = \frac{1}{m}\cdot F_1\cdot t_{Ab} \longrightarrow v_{Ab}^{Mond} = \sqrt{\frac{11}{6}}\cdot v_{Ab}^{Erde}$$

$$h = \frac{v^2}{2g} \longrightarrow h_{Mond} = 11\ h_{Erde}$$

3. Model of a movement

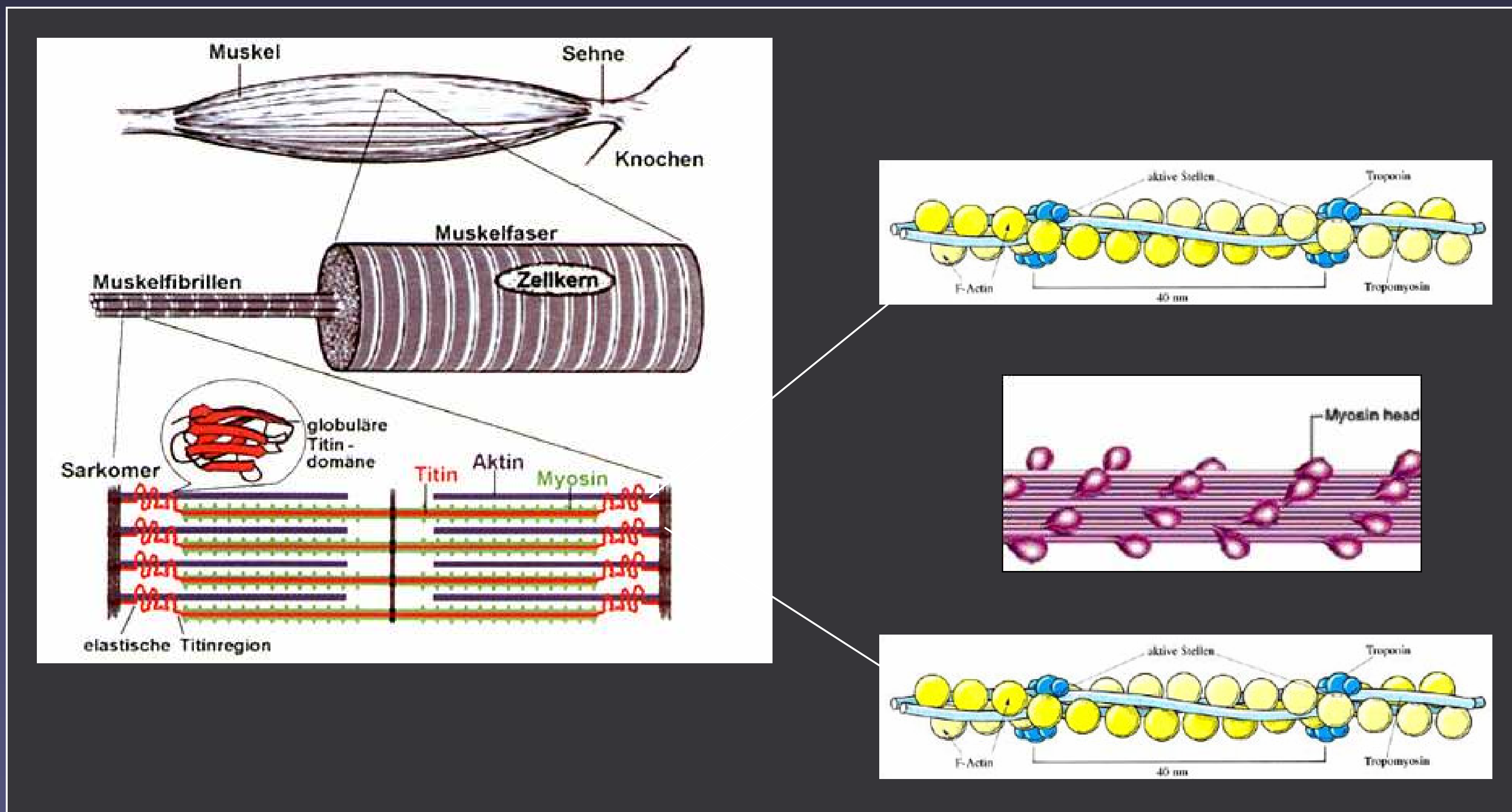


Muscle

Activation

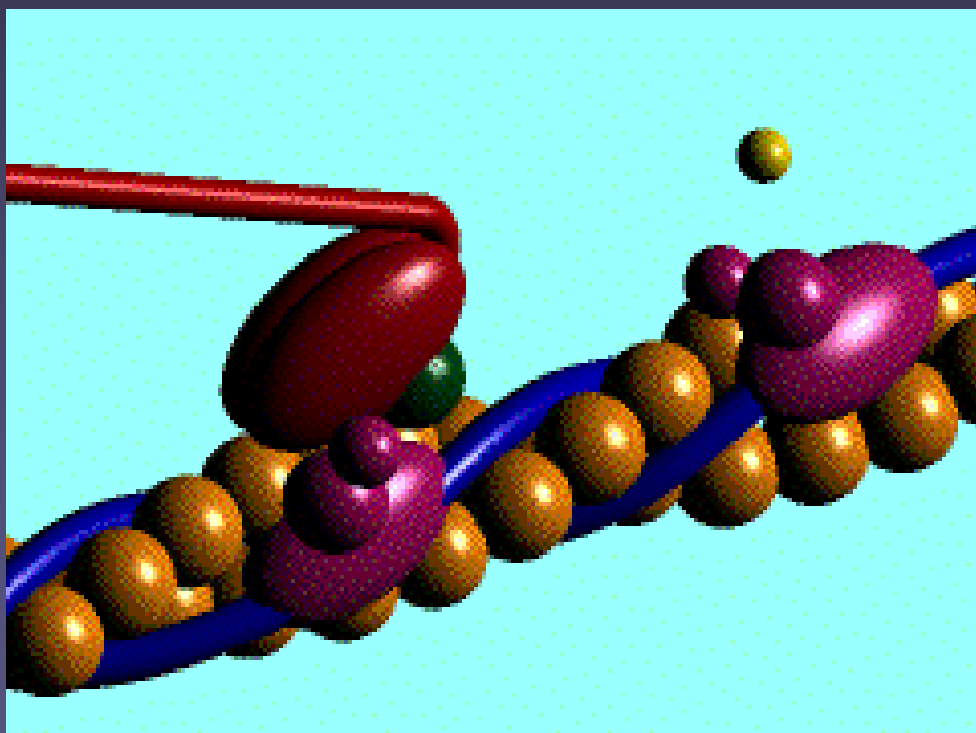
Geometry

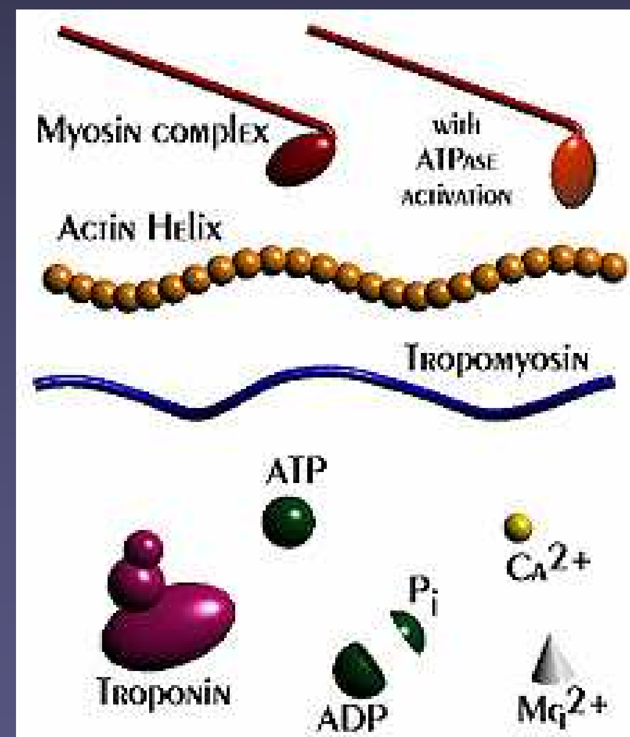
Muscle



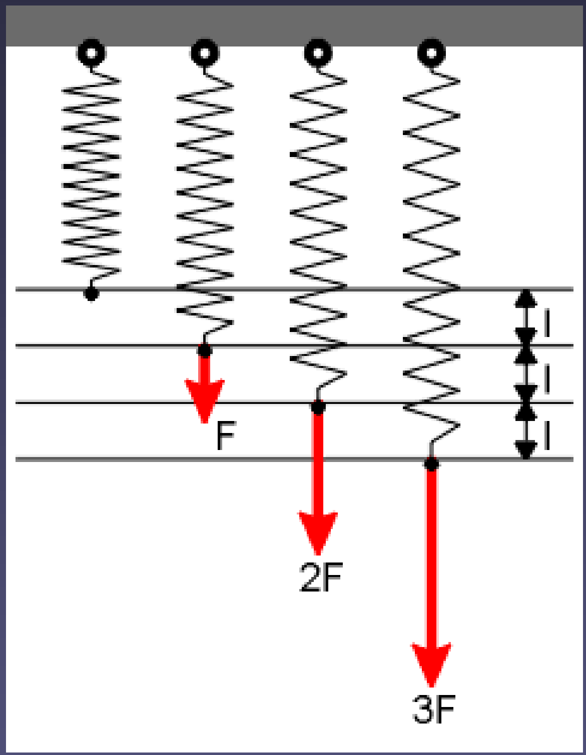
Muskel
Sehne
Knochen
Muskelfaser
Zellkern
Muskelfibrillen
globuläre Titin - domäne
Sarkomer
Titin
Aktin
Myosin
elastische Titinregion
aktive Stellen
Troponin
F-Actin
40 nm
Tropomyosin
Myosin head
aktive Stellen
Troponin
F-Actin
40 nm
Tropomyosin

Muscle




Myosin complex
with ATPase activation
Actin Helix
Tropomyosin
ATP
Troponin
ADP
P_i
Ca^{2+}
Mg^{2+}

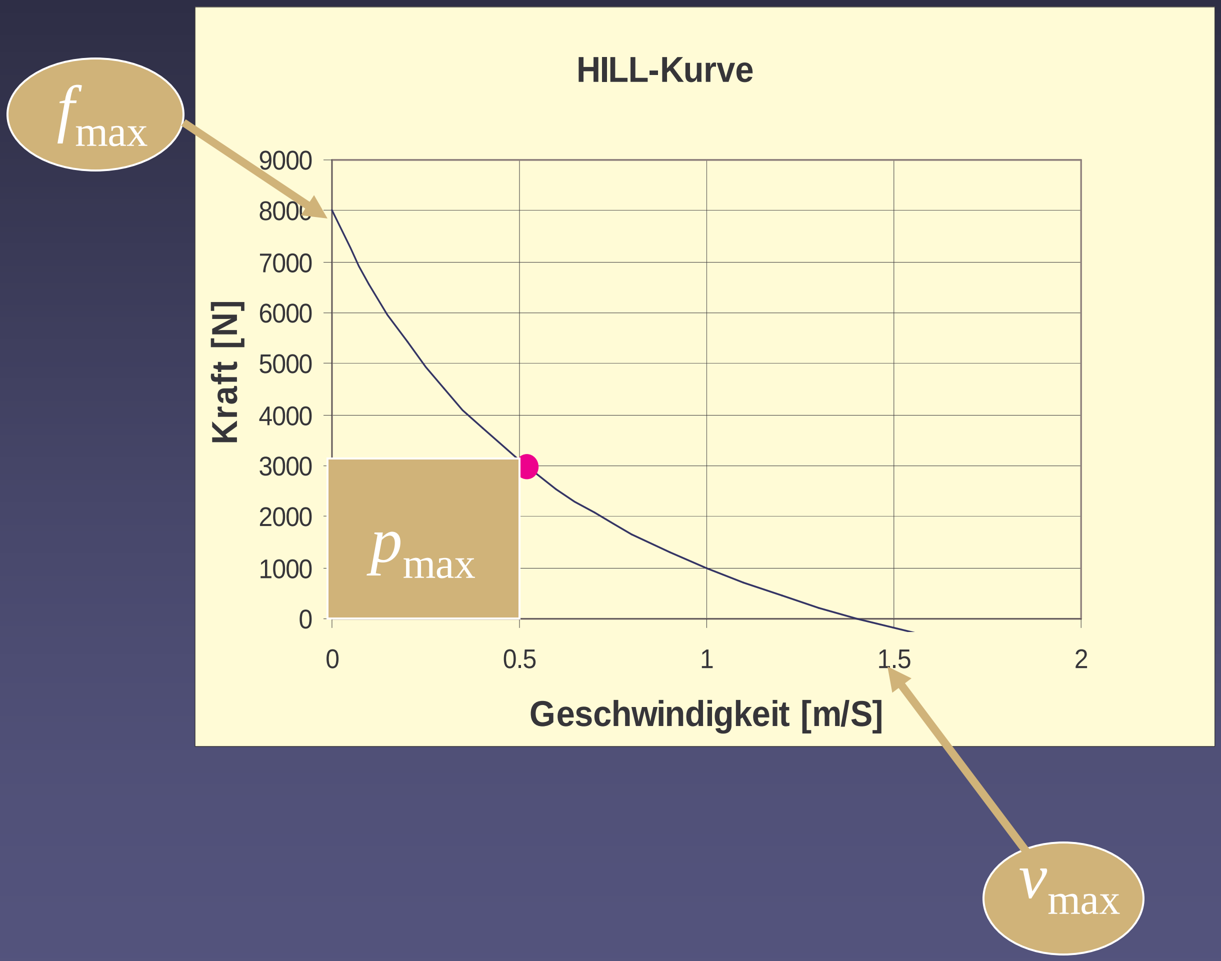
A muscle is not a spring



$F \sim x$

$F \sim v$

Force of a muscle

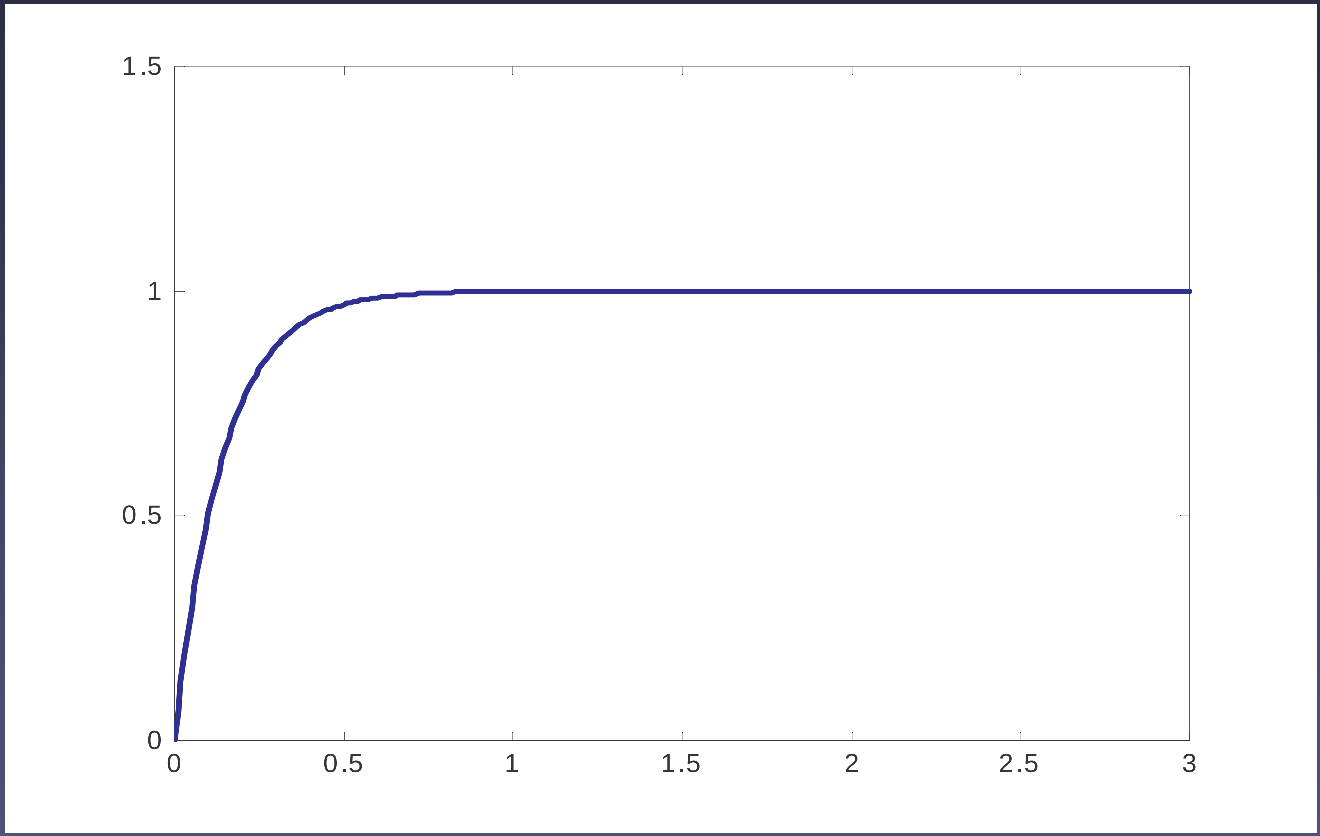


A.V. Hill

$$f = \frac{c}{v+b} - a$$

Activation

S(t)



Zeit [sec]

$$S(t) = 1 - e^{-A(t - t_0)}$$

A...Parameter der Innervation

Geometry function

$$Fm = G(X) \cdot fm$$

Fm...Kraft außen,
fm...Kontraktionskraft im Muskel

Equation of motion

$$m\frac{d^2X}{dt^2} = -mg + G(X)\cdot\left(\frac{c}{G(X)\frac{dX}{dt}+b} - a\right)\cdot S(t)$$

Gewicht

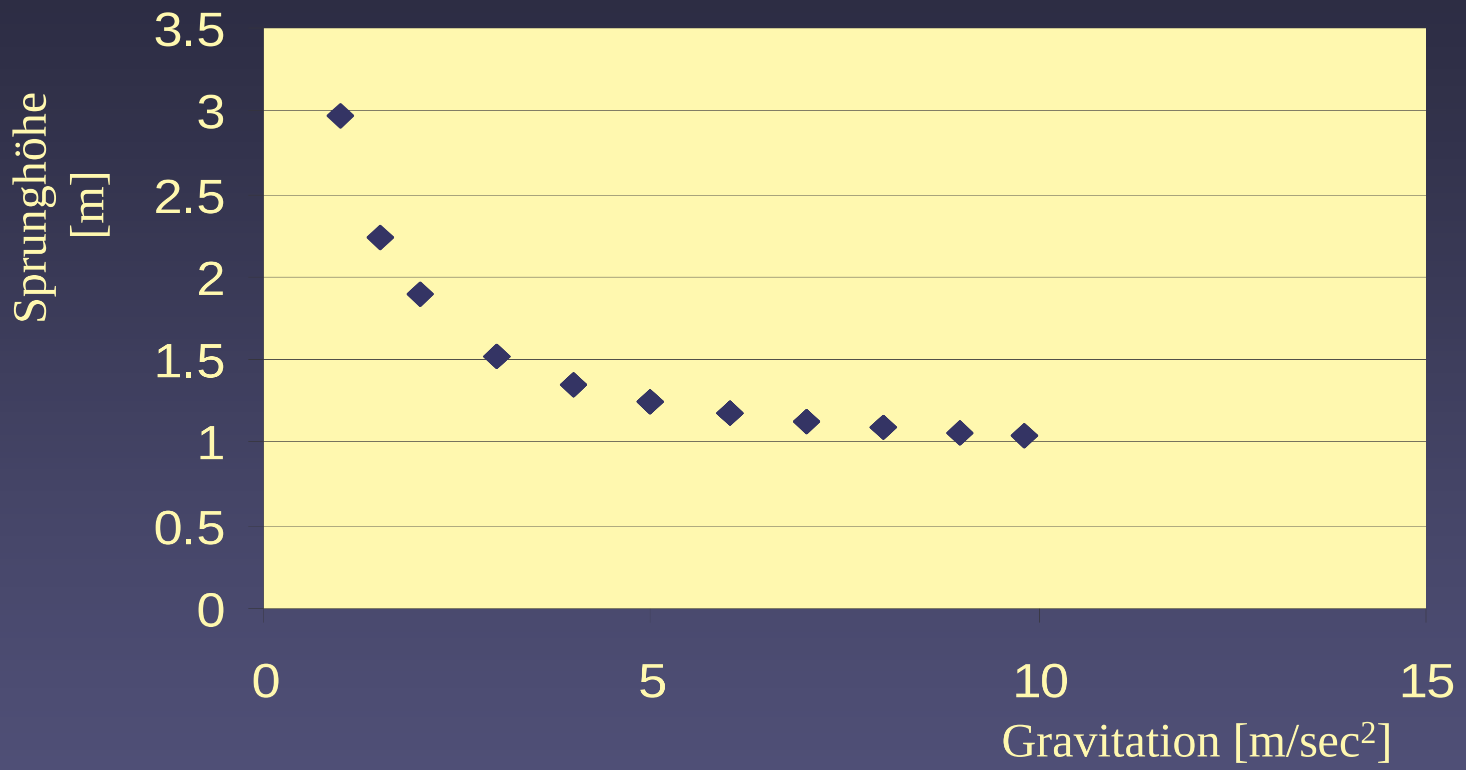
Geometrie

Hillsche Gleichung:

$$f = \frac{c}{v+b} - a$$

Aktivierung

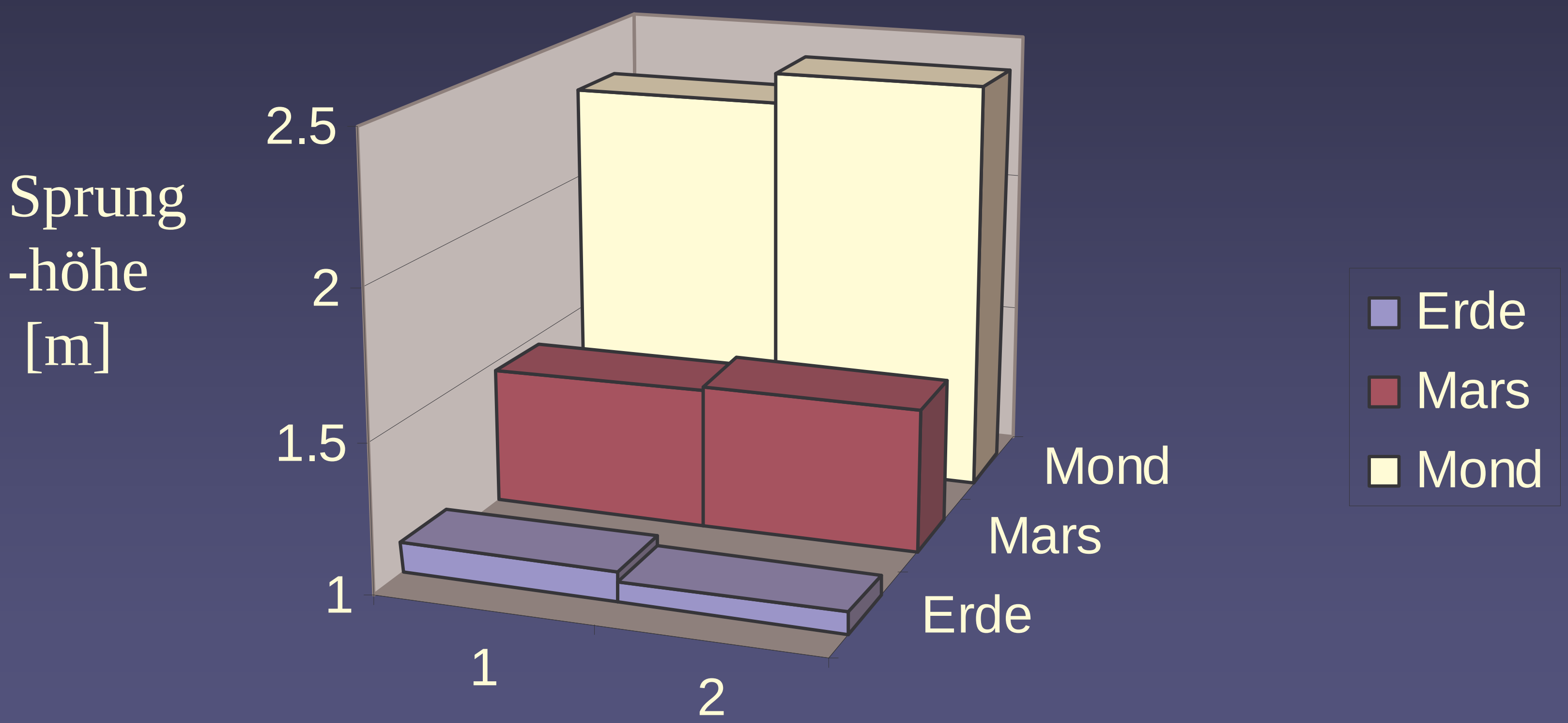
Result of the simulation

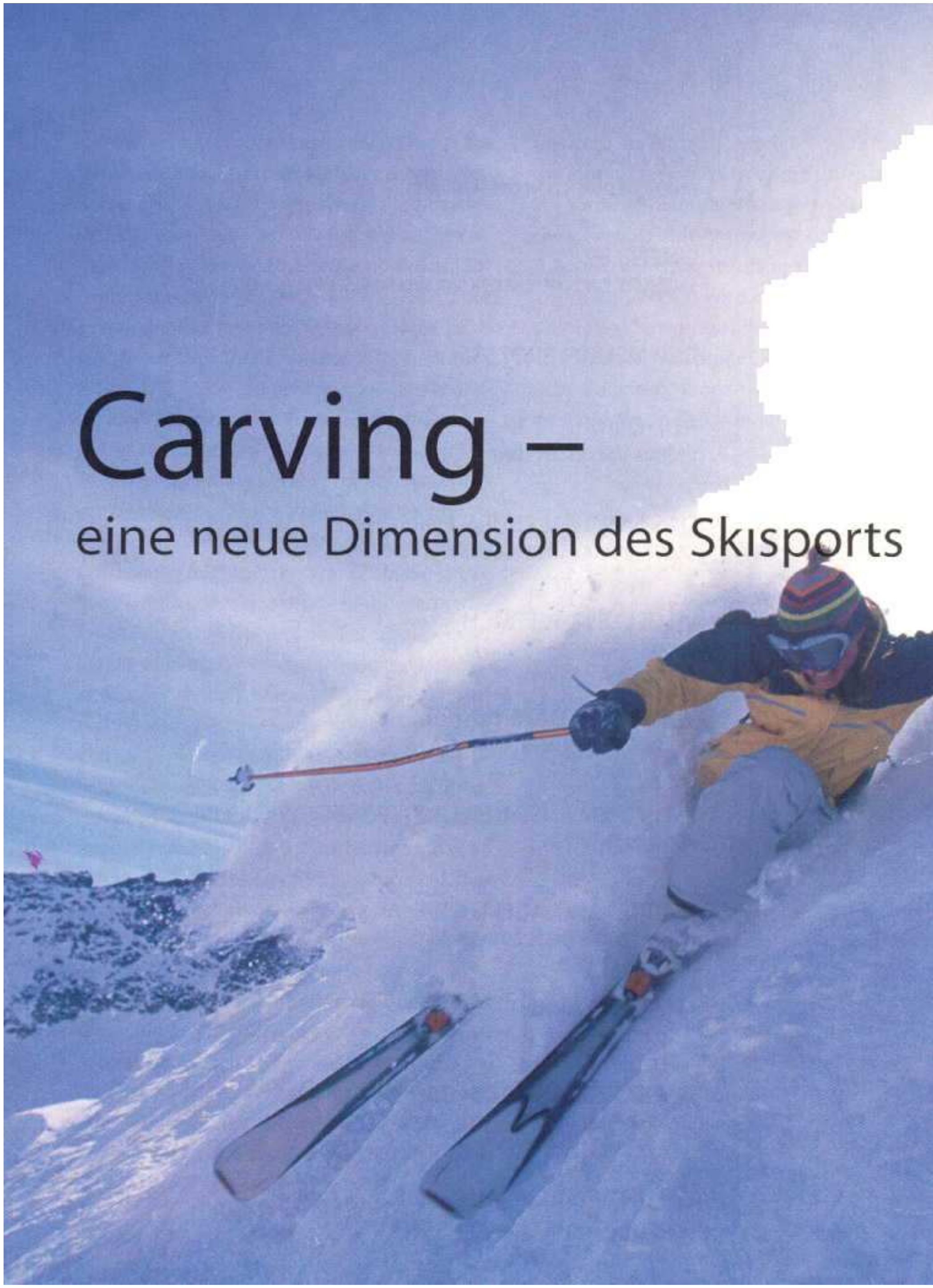


Flughöhe: 0,13 m ⟶ 1,36 m

$$h_{Mond} = 10,5\ h_{Erde}$$

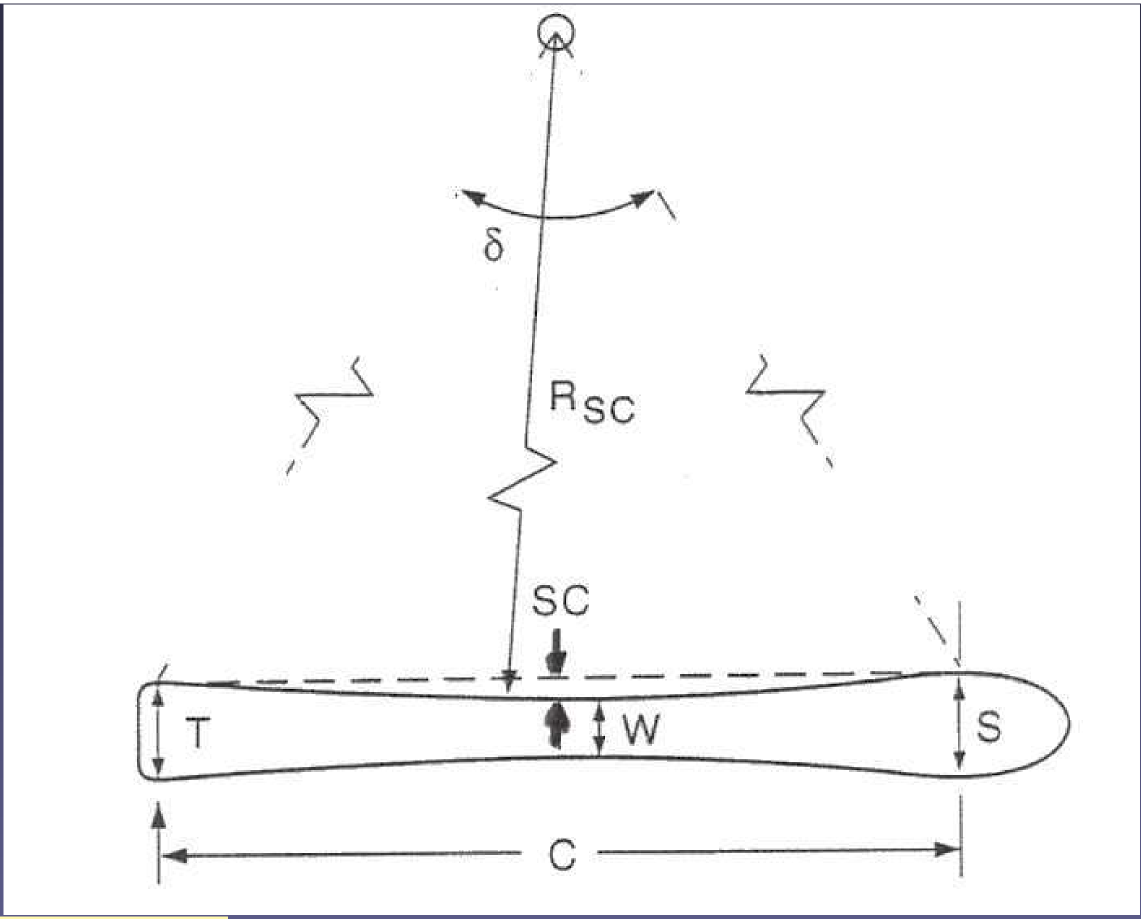
Individual effects





Physics of Carving

Curvature



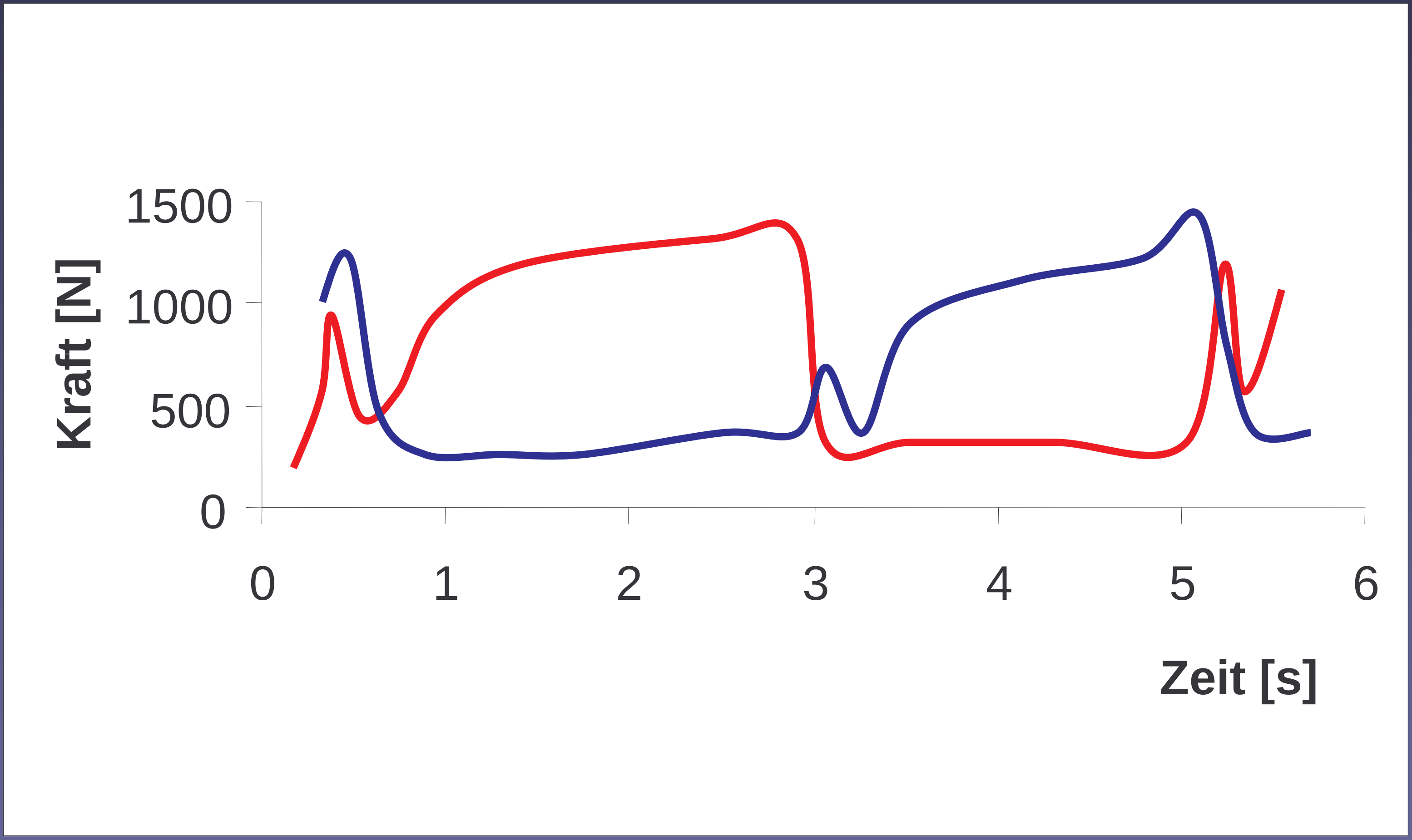
$$SC = R_{SC} - R_{SC} \cdot \cos(\delta / 2)$$

$$SC \approx R_{SC} \cdot \frac{\delta^2}{8}$$

$$C = R_{SC} \cdot \delta$$

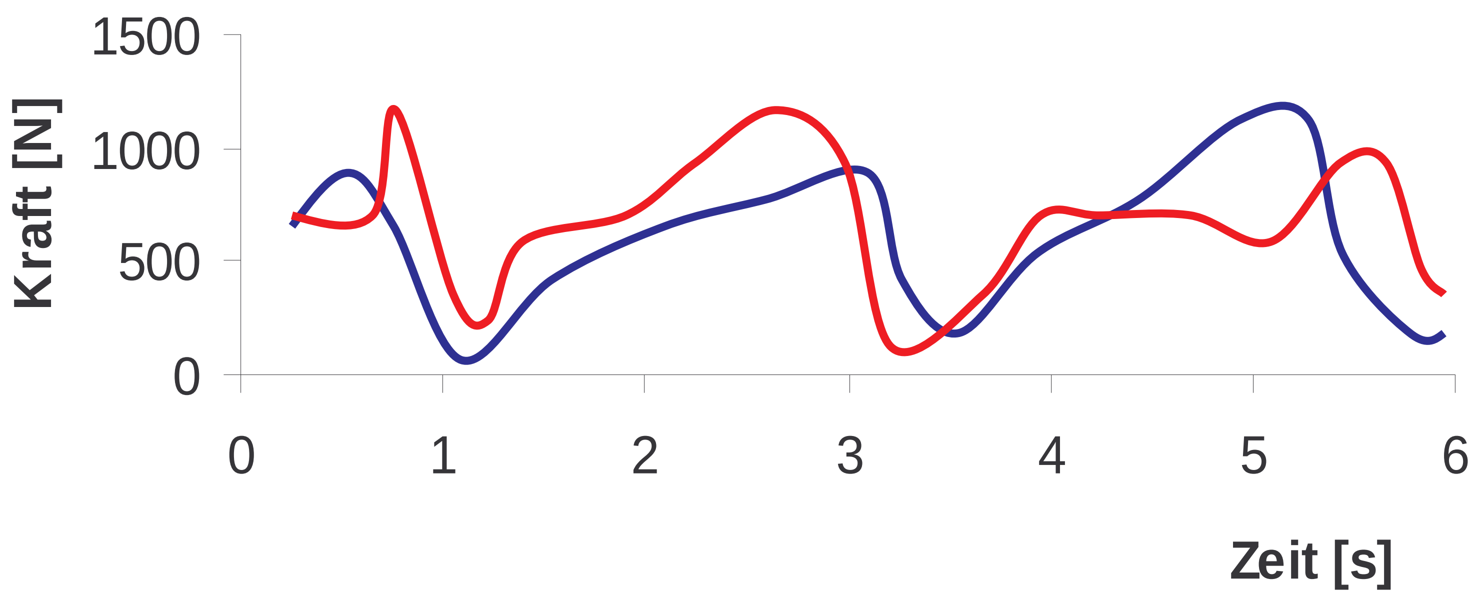
$$R_{SC} \approx \frac{C^2}{8 \cdot SC}$$

Traditional technique



Rechter Ski   Linker Ski

Carving technique

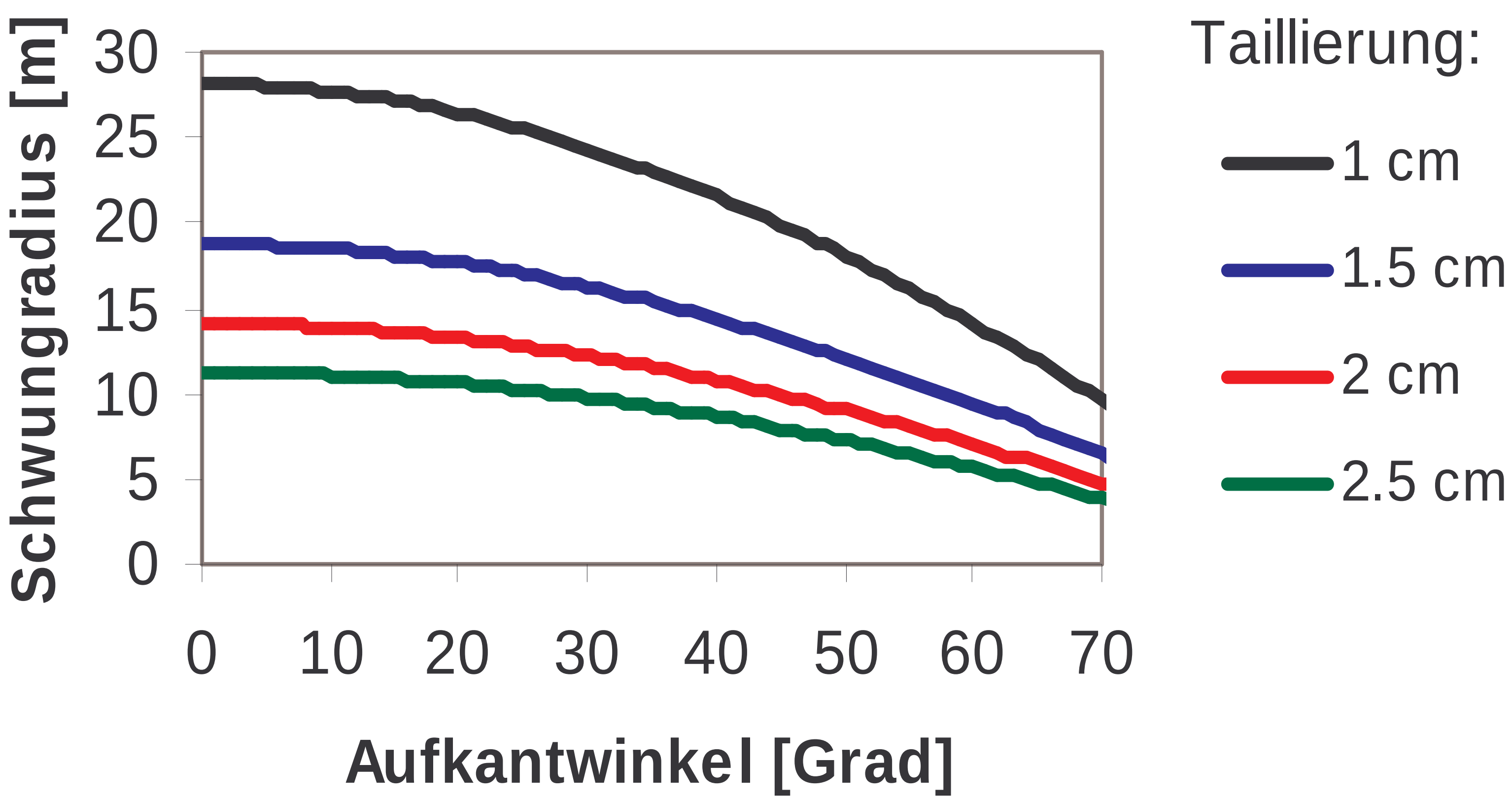


Rechter Ski

Linker Ski

Carving - Parallel

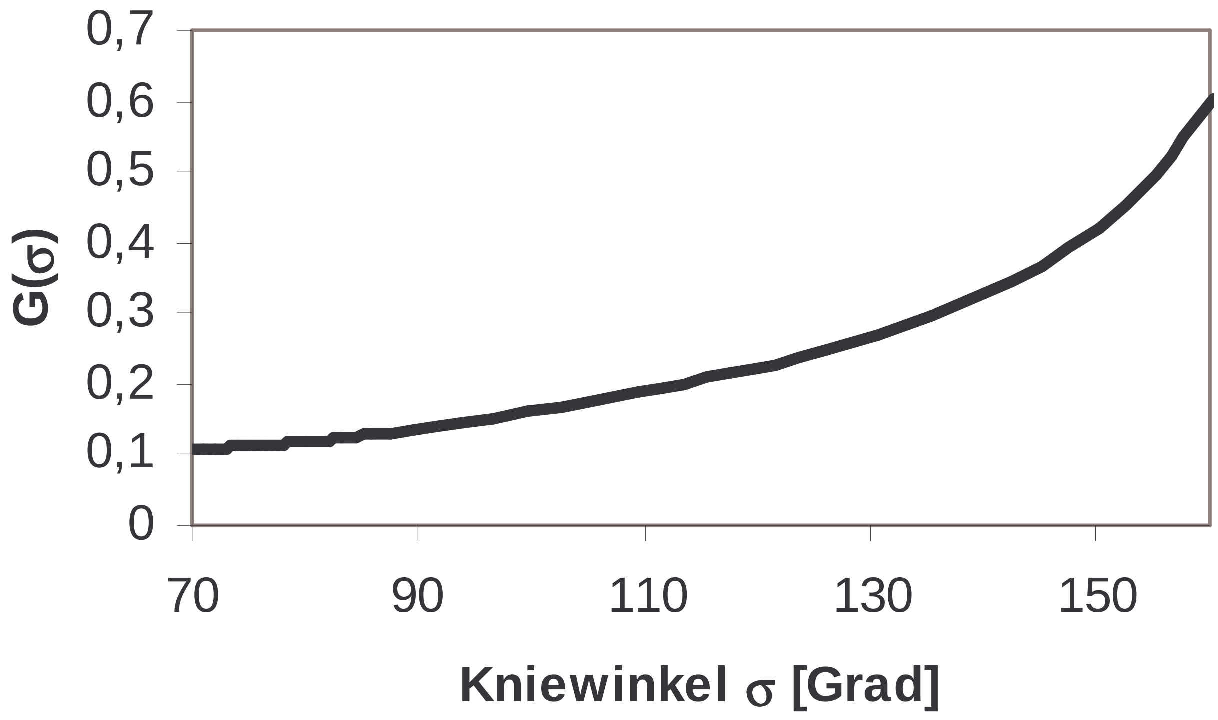
Radius



Schwungradius [m]
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
Aufkantwinkel [Grad]
Taillierung:
1 cm
1.5 cm
2 cm
2.5 cm

Geometry

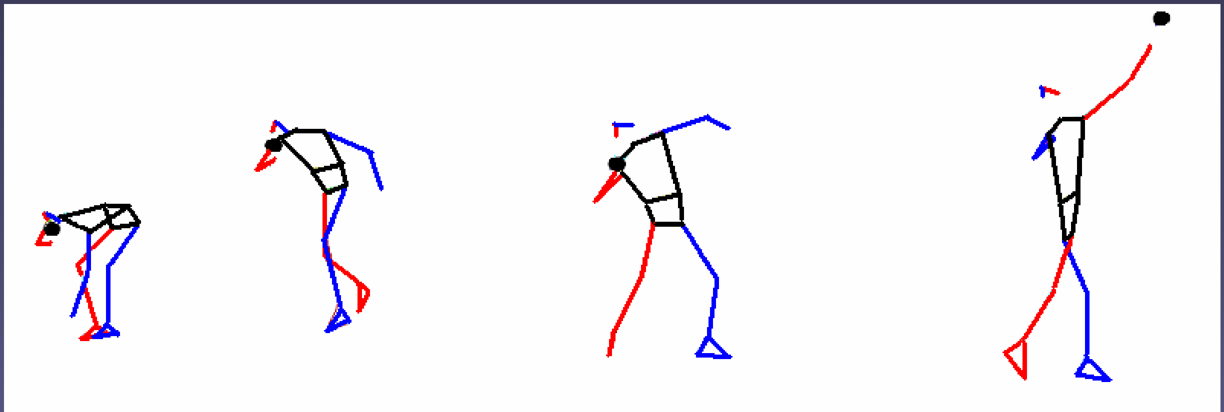
Waage
Abstand X



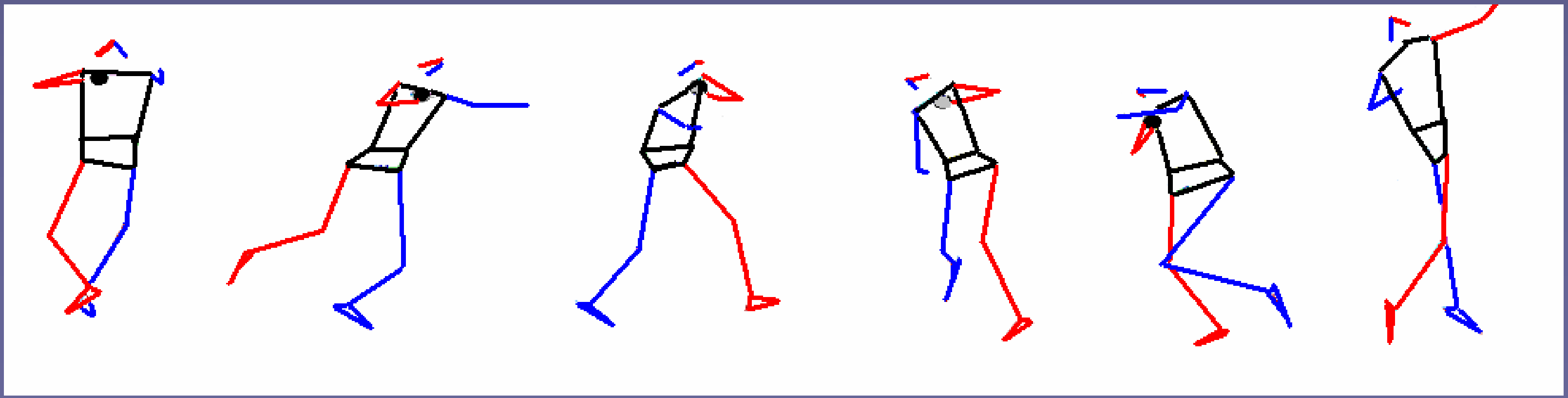
G(σ)
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
70
90
110
130
150
Kniewinkel σ [Grad]

Shotput

O´Brien technique



Rotation



Shotput - new

Cartwheel-technique