Mittuniversitetet
MID SWEDEN UNIVERSITY

3rd Mountain, Sport & Health
UPDATING STUDY AND RESEARCH FROM LABORATORY TO FIELD
International congress 12-14 November 2009, Rovereto (TN) - Italy

MUSCLE TRAINING FOR ALPINE SKIING

Per Tesch
Dept Health Sciences
Mid Sweden University
Östersund

ÅRE, SWEDEN 1977 - 2009

DISCIPLINES

Slalom: Technical; 20-40 km/hr; 45-60 sec
Giant Slalom: Technical; 20-60 km/hr; 60-90 sec
Super-G: Speed; 75 km/hr; 80-90 sec
Downhill: Speed; 100-140 km/hr; 120-180 sec

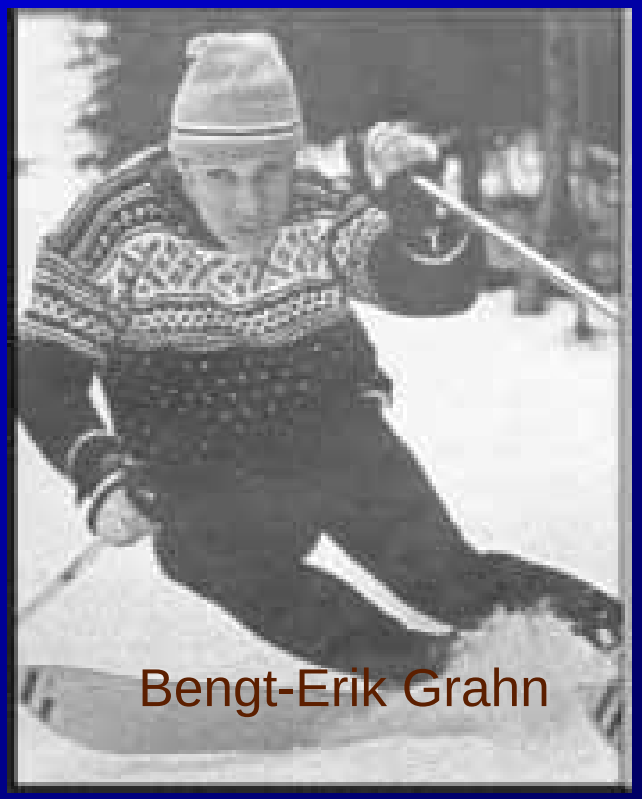
The fact that many skiers compete successfully in several disciplines would suggest that the physiological needs across the four events are not that different?

or

May it be that on and off snow training for the four disciplines lacks adequate specificity?

ALPINE SKIING FROM LATE 60's TO NOW

Bode Miller



Bengt-Erik Grahn

CALL FOR POWER AND ENDURANCE IN GS SKIING

HIGH FORCES
4 g while turning

HEAVY ECCENTRIC LOADING
Slow and sustained muscle actions

ENDURANCE EVENT
40 directional changes over 90 sec

ARE THE ENERGY DEMANDS DIFFERENT TODAY?

Equipment, courses, technique, skill and athlete selection, body stature, fitness and conditioning approaches have evolved

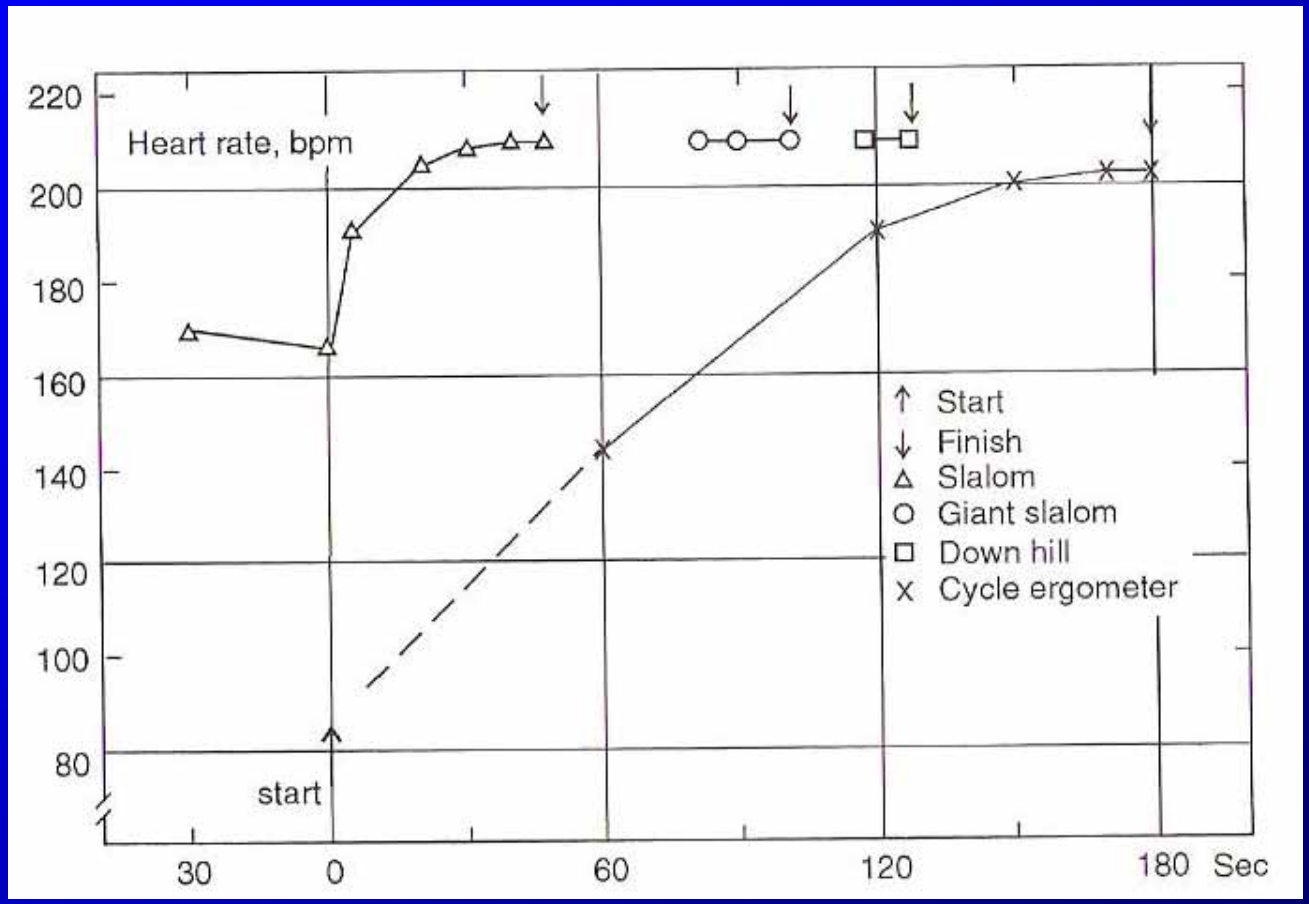
Yet, energy requirements and skeletal muscle metabolism remains basically the same.

See other sports

ENERGY DEMANDS IN SKIING

Mittuniversitetet
MID SWEDEN UNIVERSITY

HEART RATE IN SKIING



ENERGY DEMANDS IN SKIING

OXYGEN UPTAKE DURING SKIING

GIANT SLALOM: 75-100% VO2max

GS>SG>S>D ??

MAXIMAL AEROBIC POWER IN SKIERS

Table III. Aerobic capacity of Alpine skiers

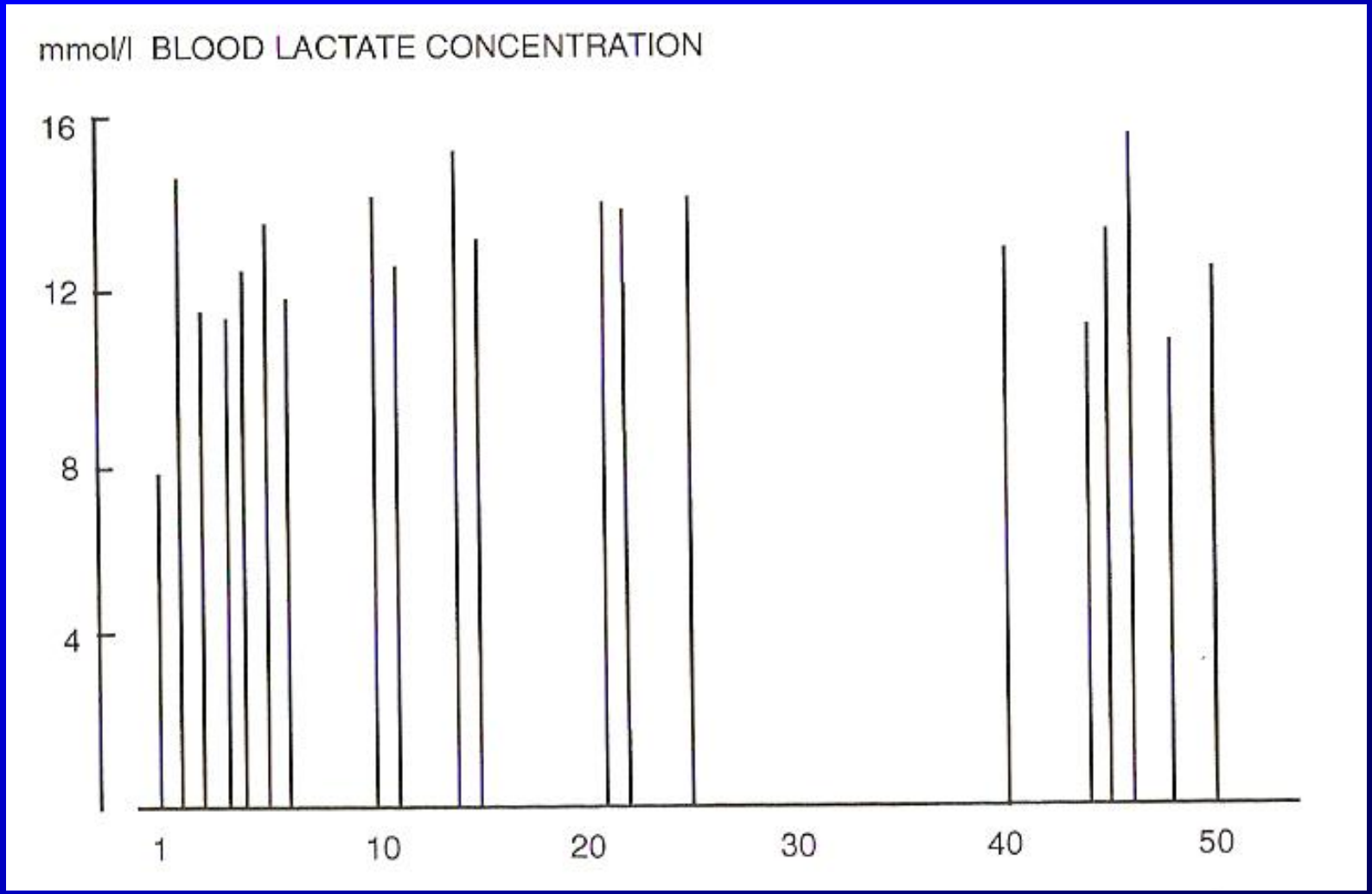
Nationality	Level	Sex	$\dot{V}O_{2max}$ (ml/kg/min)	Reference
Sweden	Ingemar Stenmark	M	70.0	Åstrand & Rodahl (1986)
US	National	M	66.6	Haymes & Dickinson (1980a)
Canadian	Junior racers	M	65.6	Song (1982)
Swedish	National	M	65.0	Bergh et al. (1978)
Swedish	National	M	63.8	Rusko et al. (1978)
Canadian	National	M	63.1	Brown & Wilkinson (1983)
Canadian	Club skiers	M	61.6	Brown & Wilkinson (1983)
Canadian	Divisional racers	M	60.2	Andersen & Montgomery (1987)
Czech.	Junior ski racers	M	60.1	Mackova et al. (1982)
Italian	National	M	58.9	Saibene et al. (1985)
Canadian	Provincial racers	M	55.6	Andersen (1988)
Canadian	Divisional racers	M	54.8	Andersen (1988)
Italian	National ski team	M	52.4	Veicsteinas et al. (1984)
Canadian	Club racers	M	50.2	Andersen (1988)
US	Varsity ski racers	M	49.1	Haymes & Dickinson (1980b)
US	National	F	53.1	Haymes & Dickinson (1978)
US	National	F	52.7	Haymes & Dickinson (1980a)

NATIONAL TEAMS: 4.8-5.3 L/min; 63-69 ml/kg/min

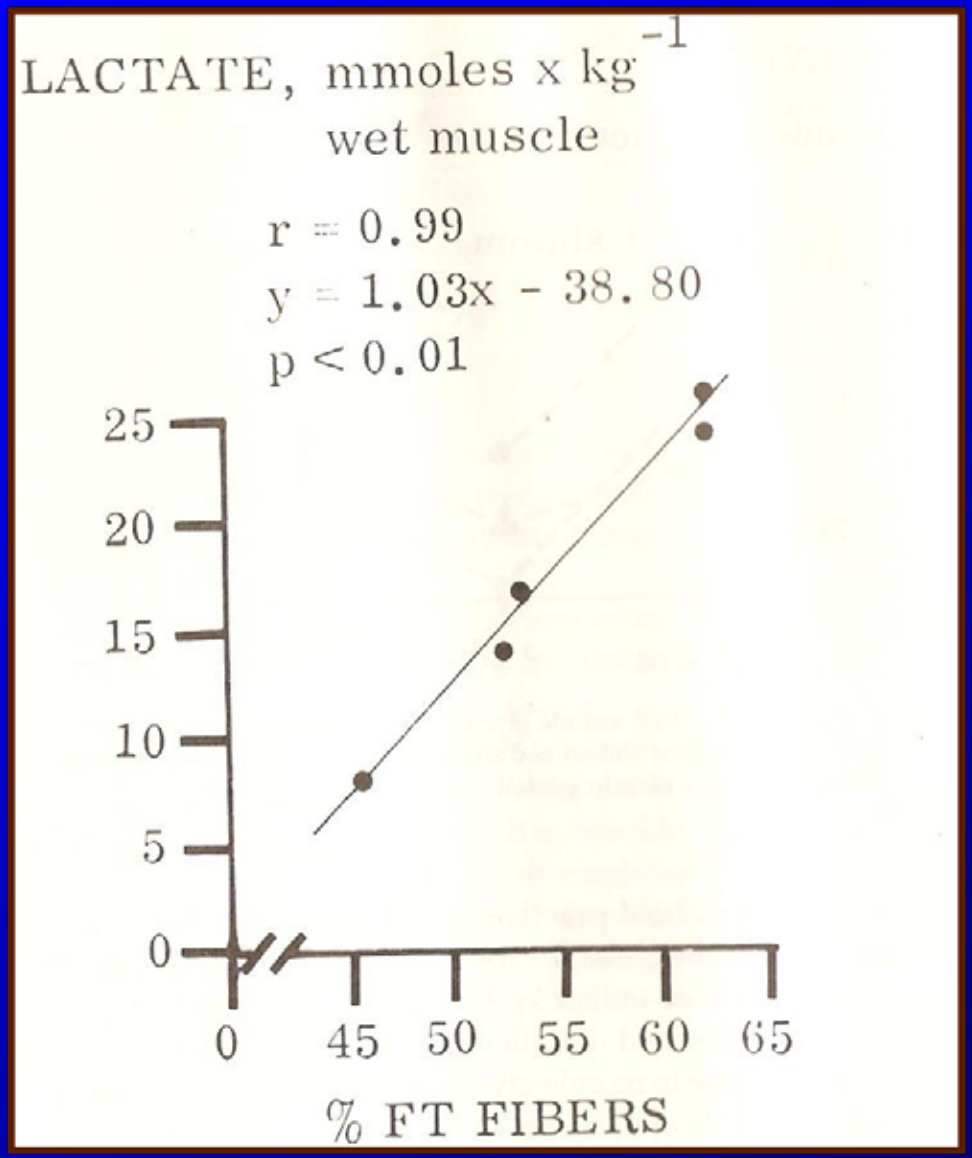
Today most teams are less willing to report

MUSCLE METABOLISM IN SKIING

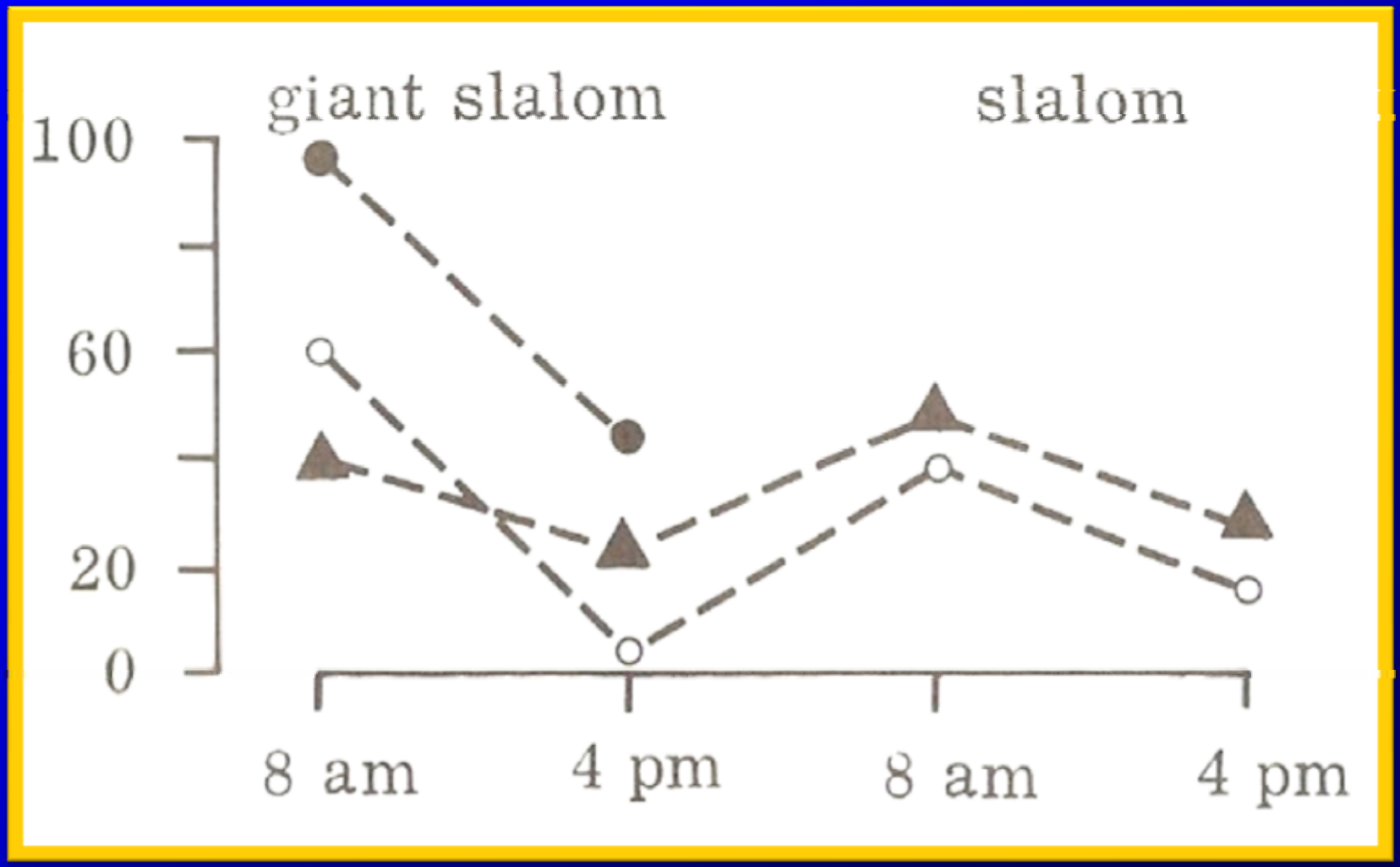
BLOOD LACTATE CONCENTRATION POST SKIING



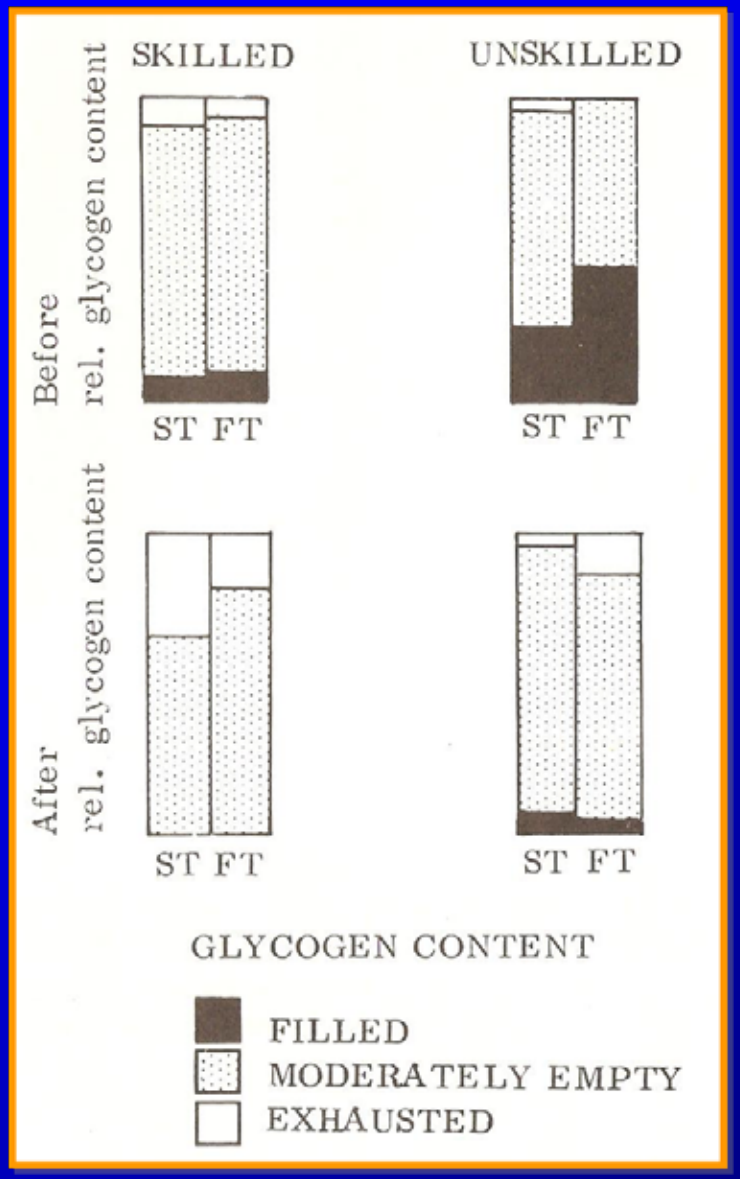
MUSCLE LACTATE CONTENT POST GIANT SLALOM



MUSCLE GLYCOGEN DEPLETION DURING SKIING



FIBER TYPE SPECIFIC GLYCOGEN UTILIZATION

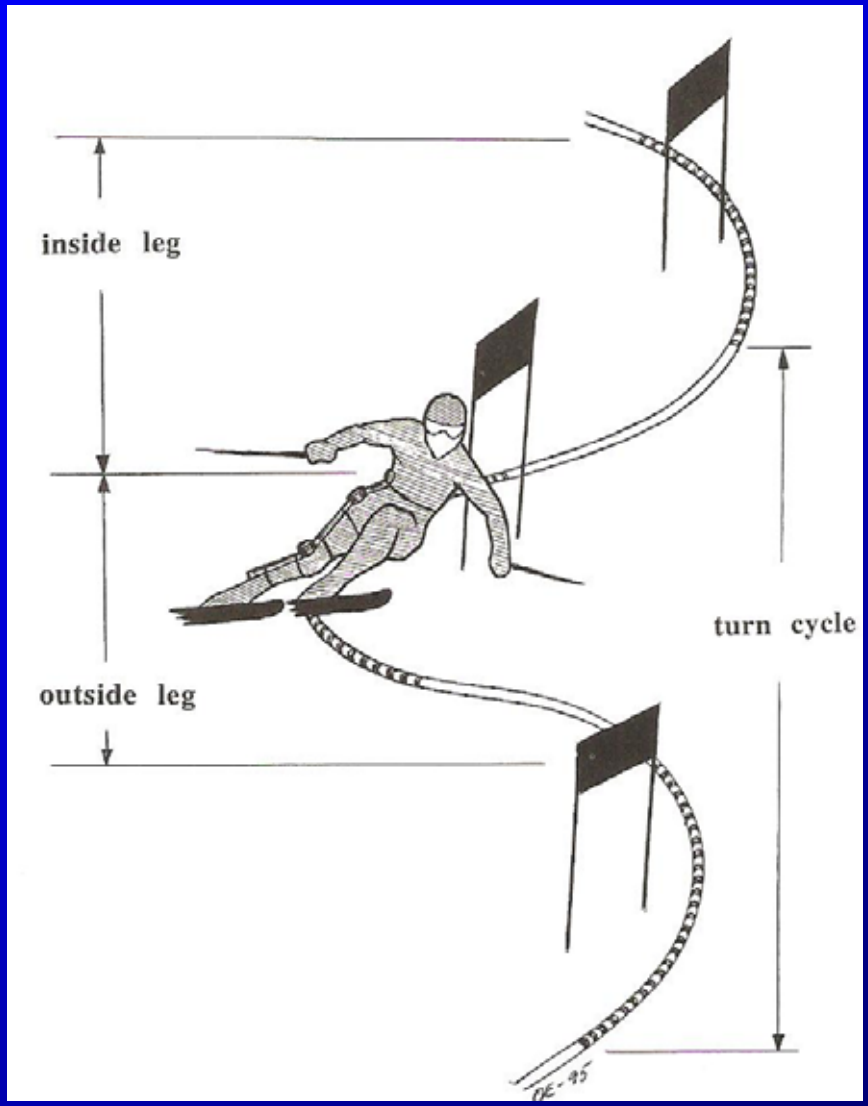


ANAEROBIC COMPONENT IN SKIING IS PREDOMINANT

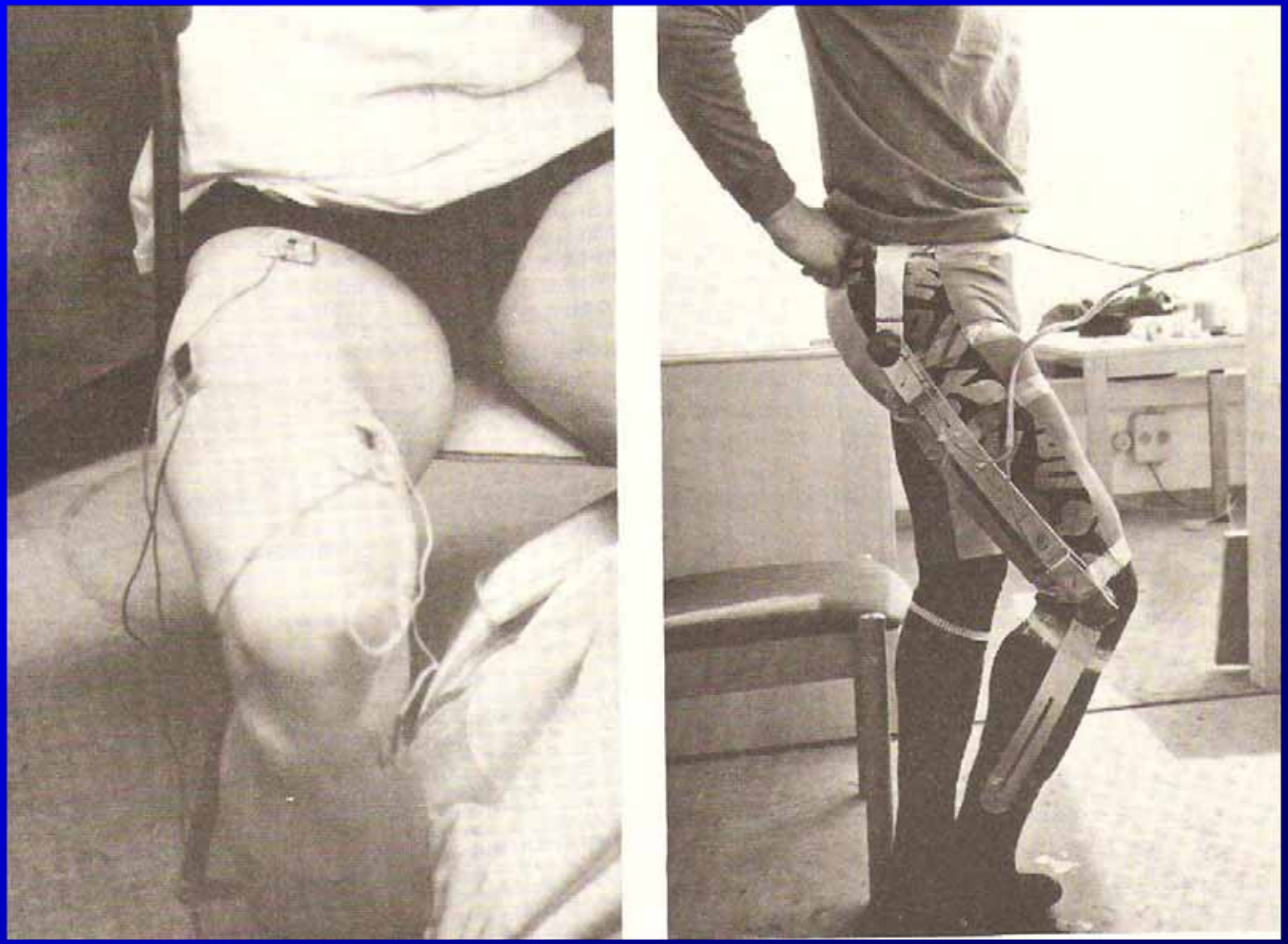
WHILE THE ENERGY REQUIREMENT MAY EXCEED 150%OF VO2max, THE MAJORITY OF ENERGY ENERGY APPEARS TO BE PROVIDED THROUGH ANAEROBIC ENERGY SOURCES.

ESTIMATED FORCES IN ALPINE SKIING

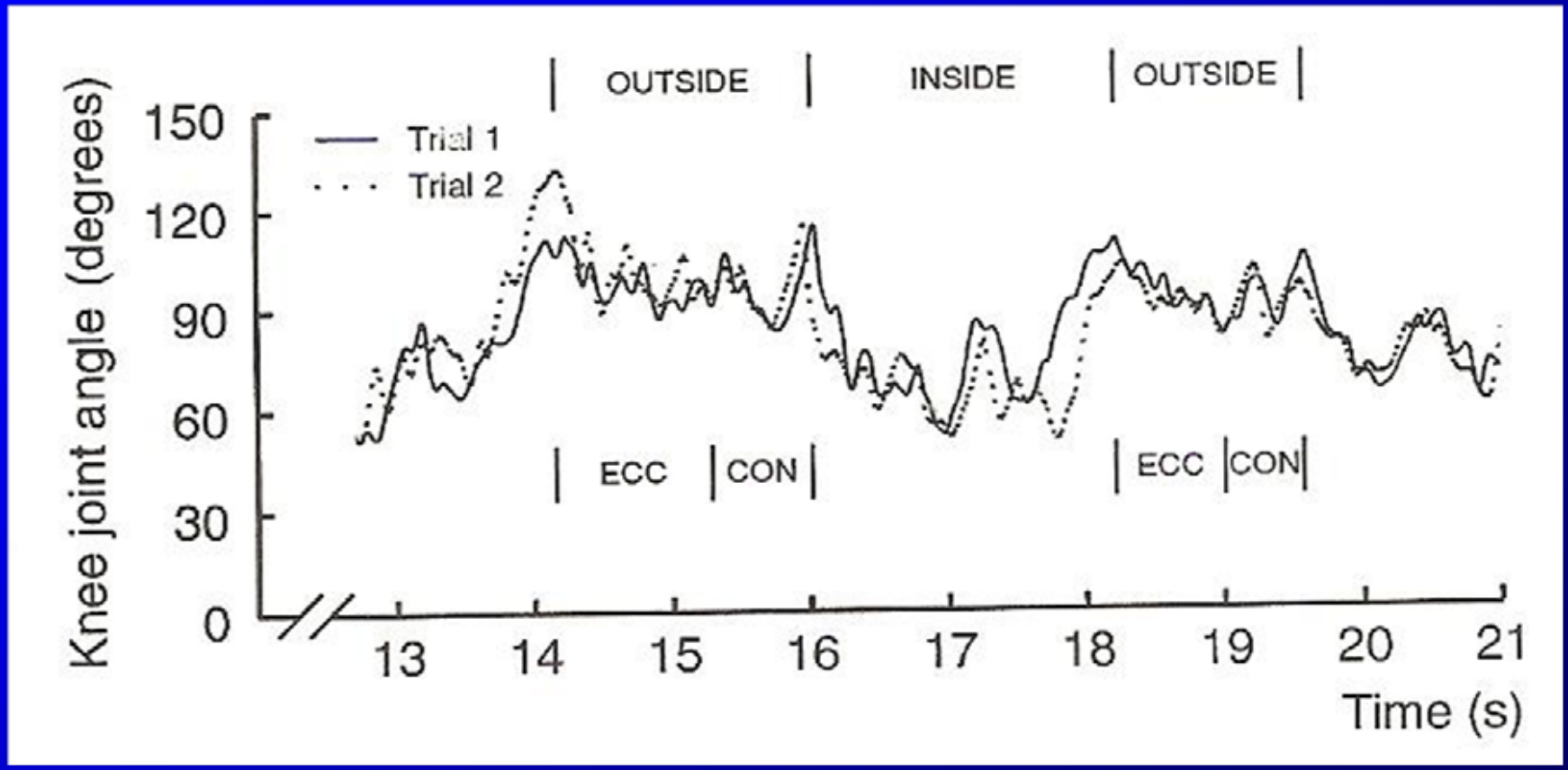
MUSCLE USE & JOINT ANGLES IN THE GIANT SLALOM



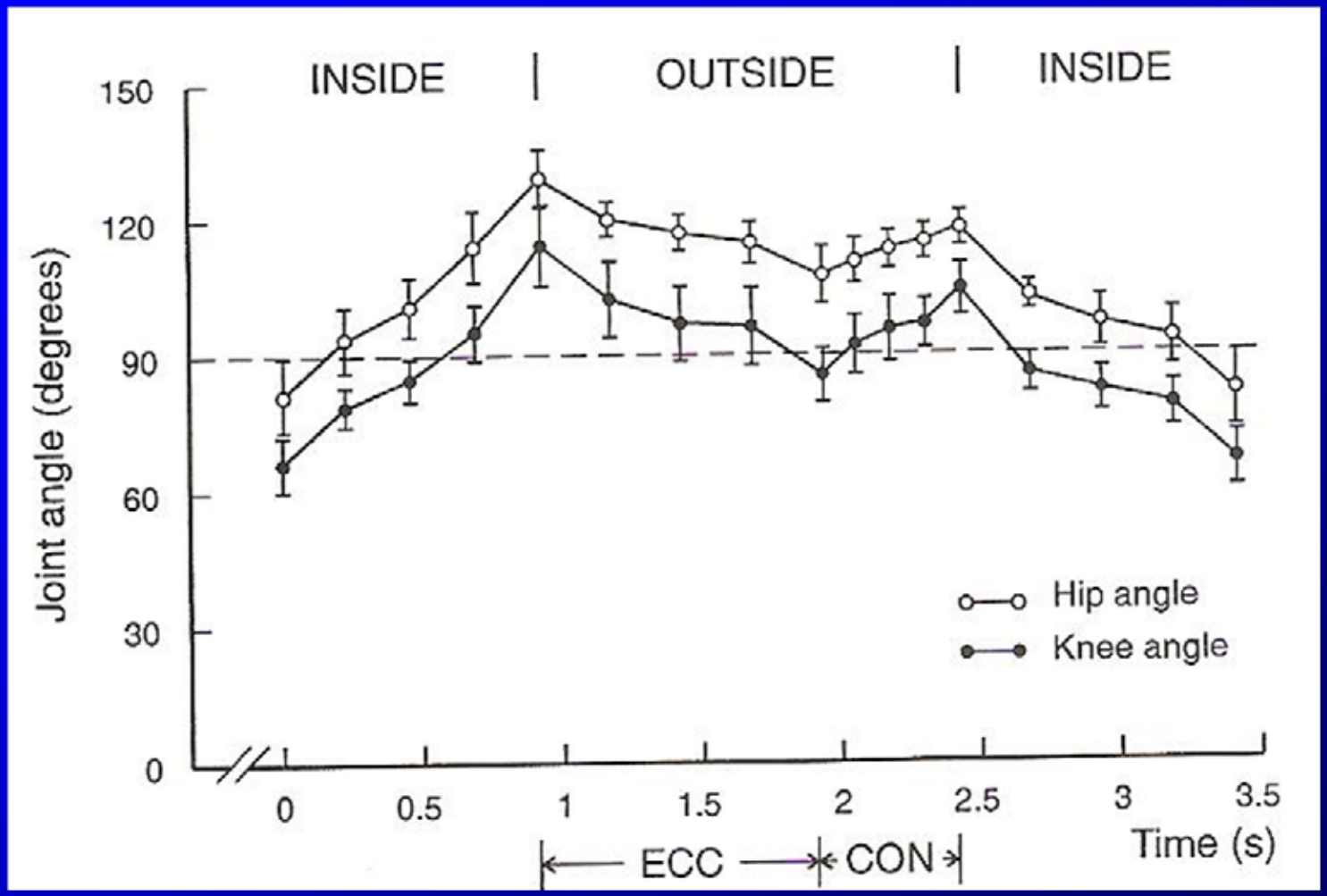
ASSESSING EMG AND JOINT MOVEMENT ON SNOW



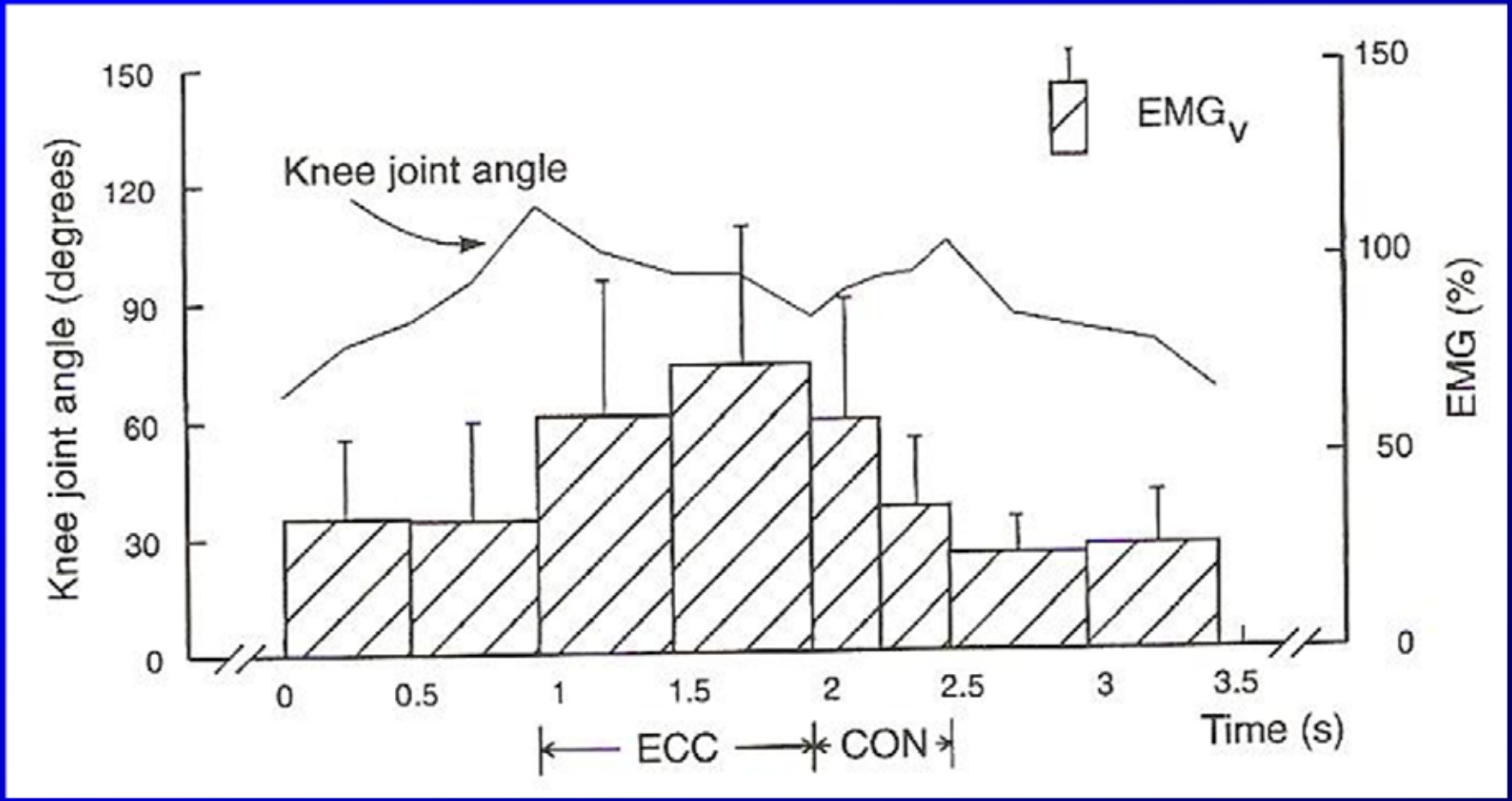
KNEE JOINT ANGLE IN THE GIANT SLALOM



KNEE & HIP JOINT ANGLE IN THE GIANT SLALOM



EMG & KNEE JOINT ANGLE IN THE GIANT SLALOM



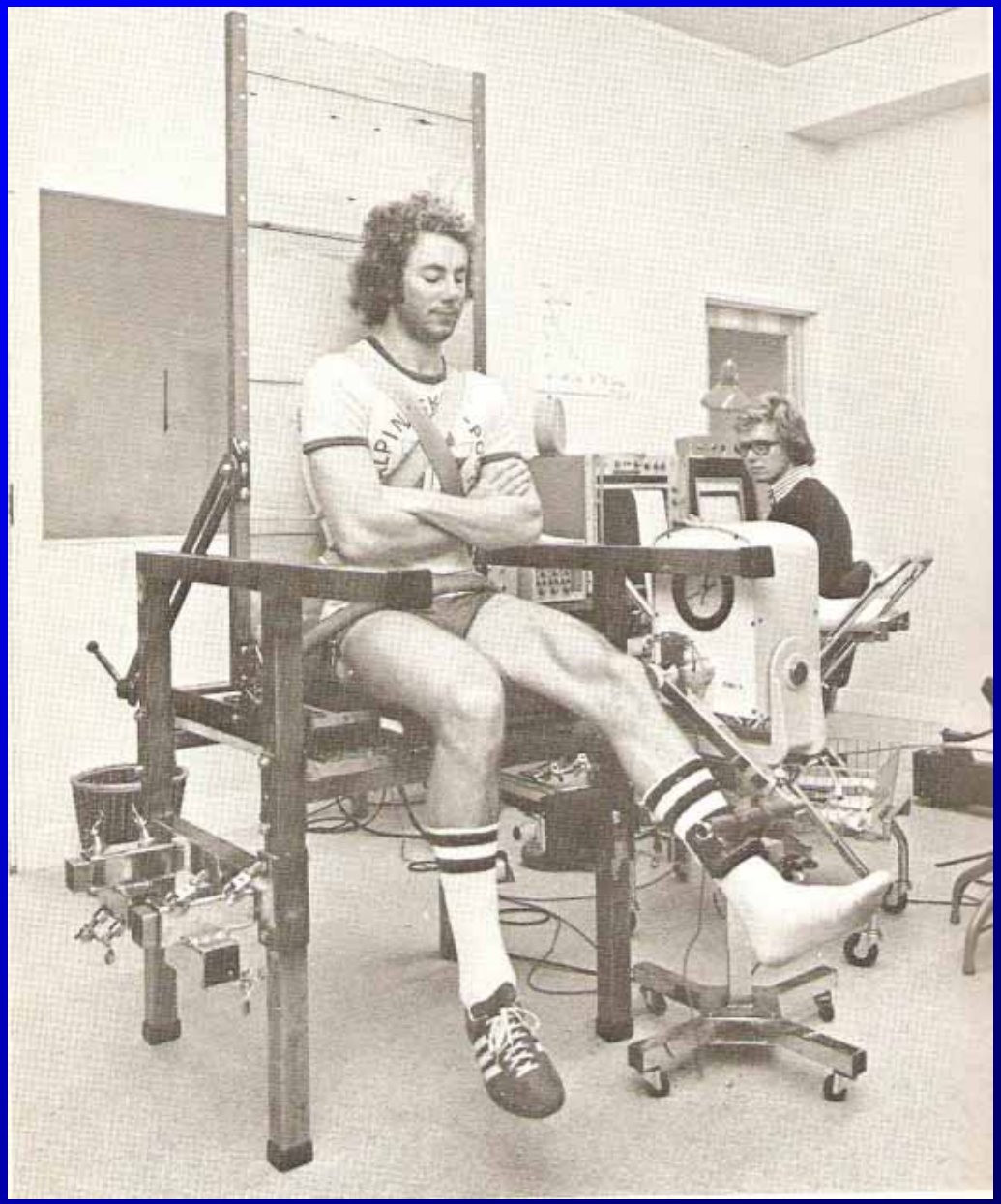
FORCES IN ALPINE SKIING

EXTRAORDINARY GROUND REACTION FORCES (SEVERAL TIMES THE BODY WEIGHT)

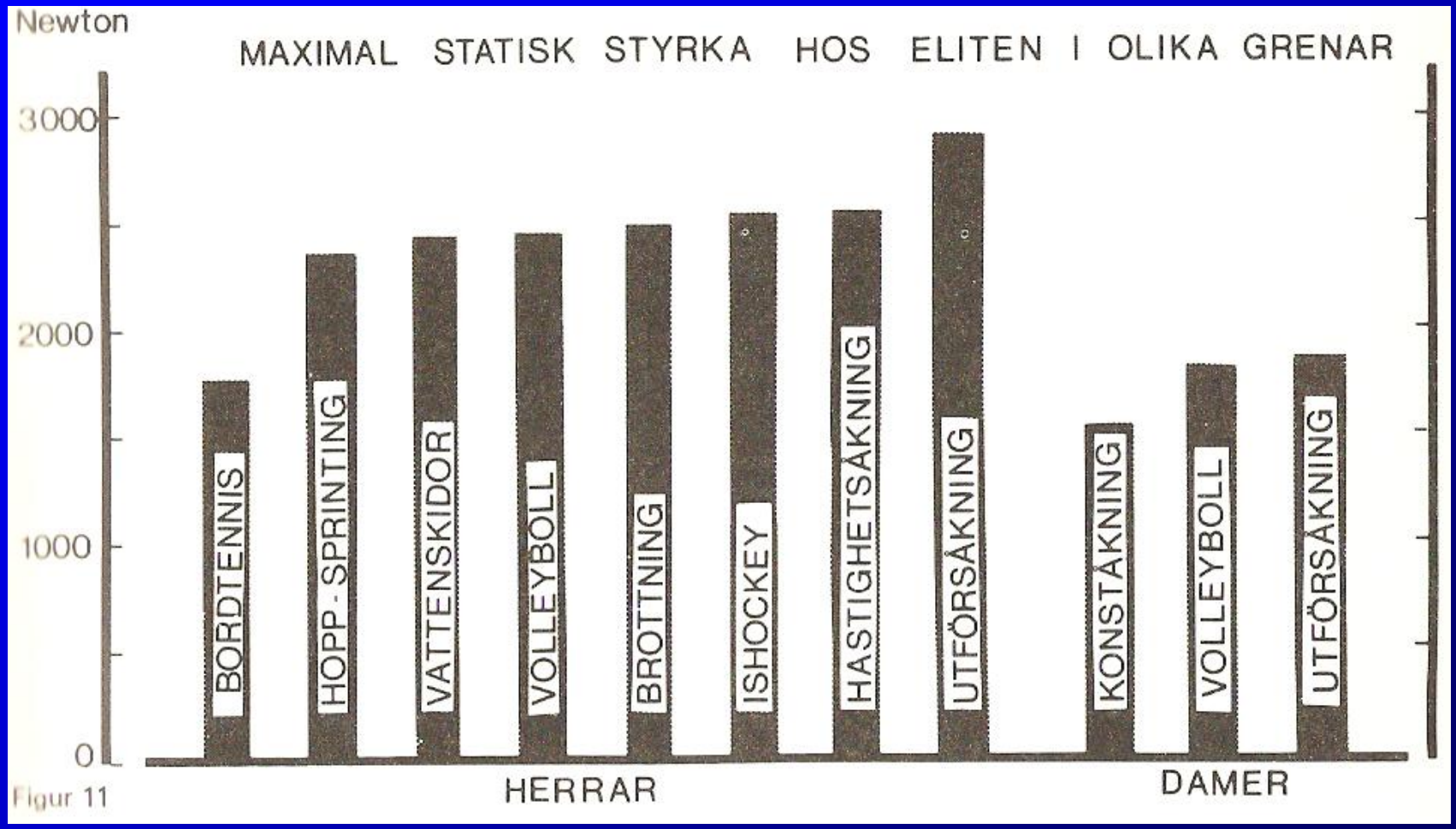
EMPHASIS ON ECCENTRIC SUSTAINED; SLOW SPEED ACTONS

PRIMARILY KNEE EXTENSORS BUT ALSO ADDUCTORS, KNEE FLEXOR AND GLUTEAL MUSCLES

MUSCLE STRENGTH IN SKIERS

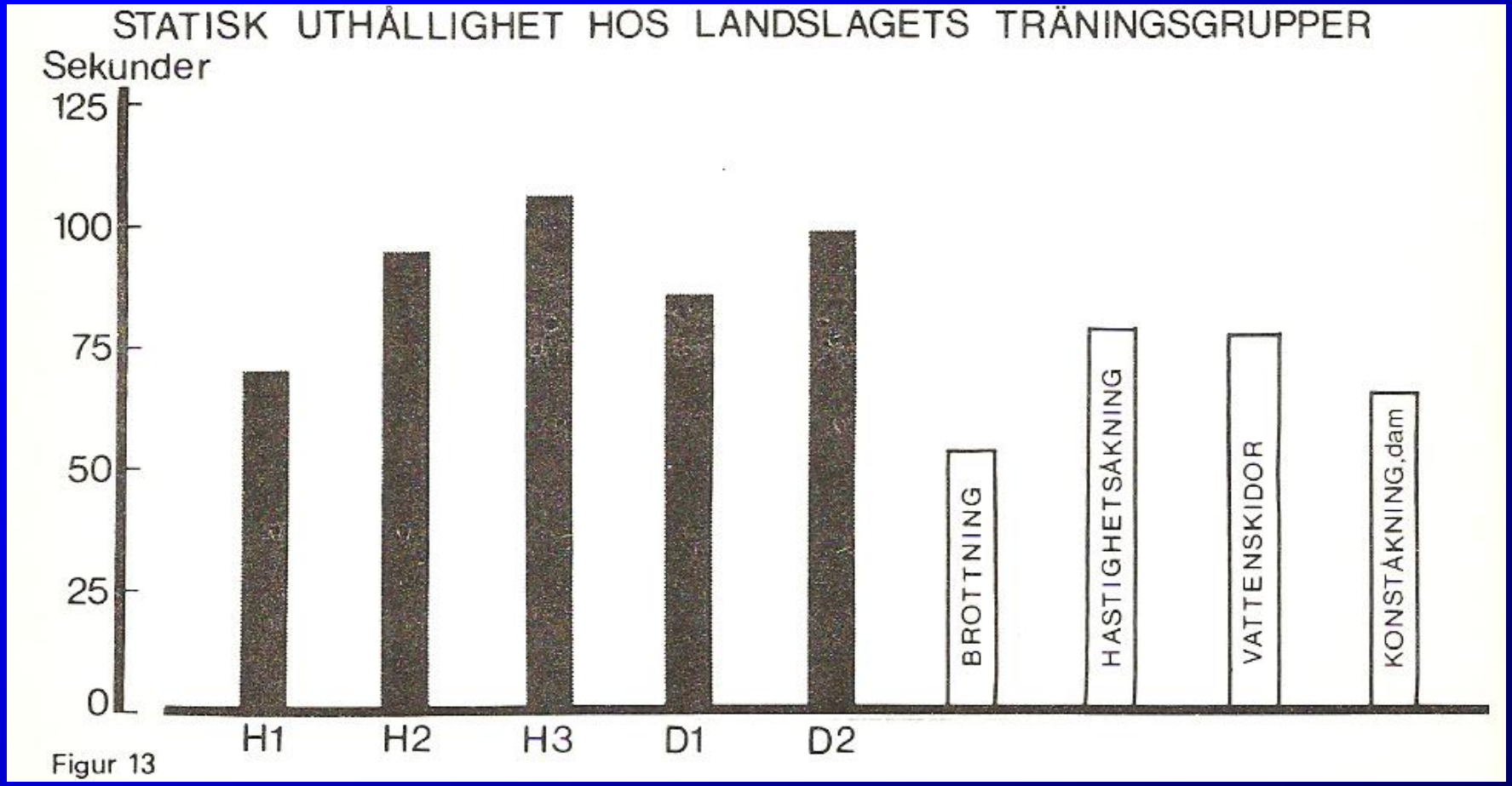


MAXIMAL ISOMETRIC FORCE (LEG PRESS) IN SKIERS



Figur 11

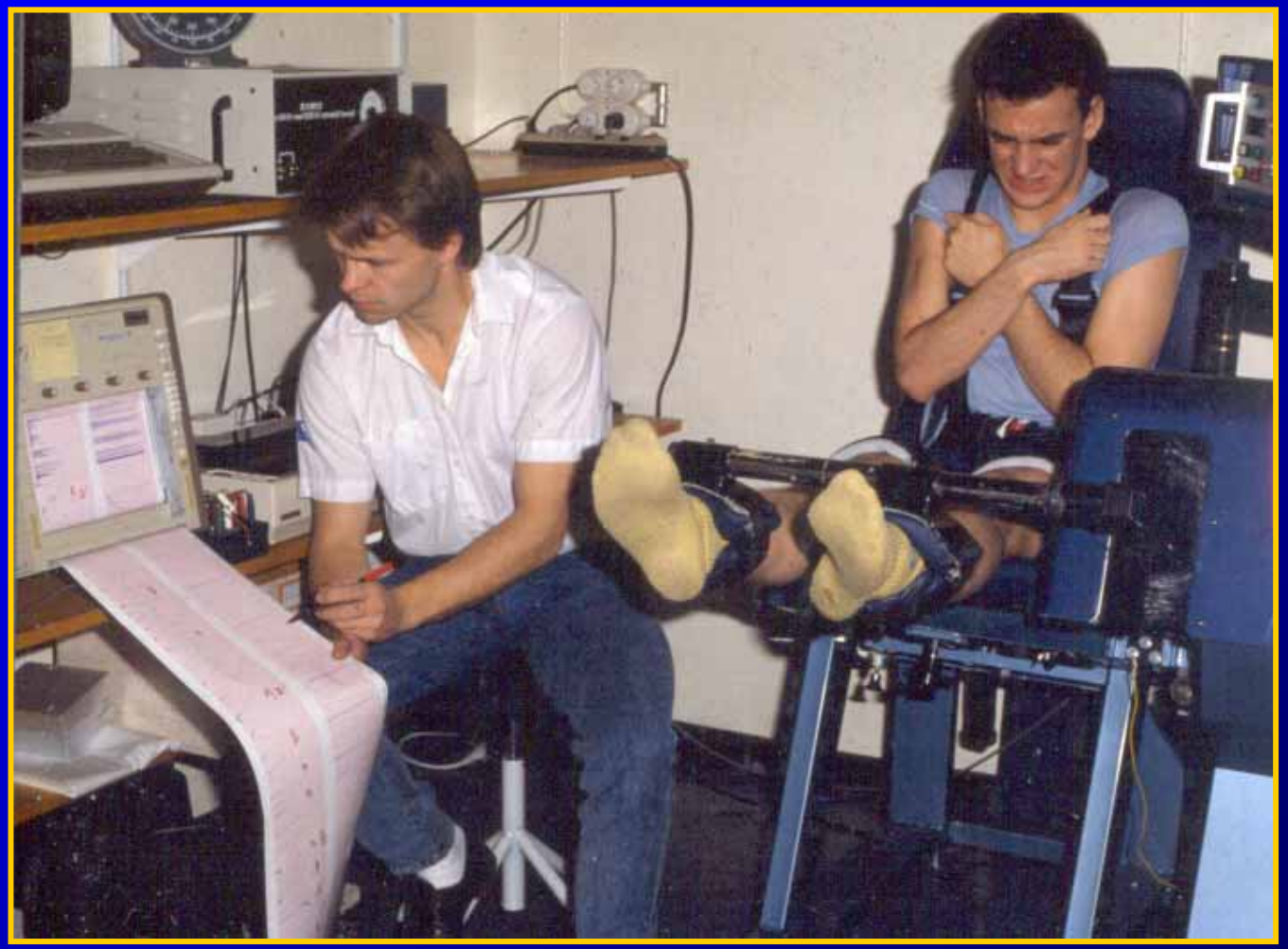
ISOMETRIC ENDURANCE (LEG PRESS) IN SKIERS



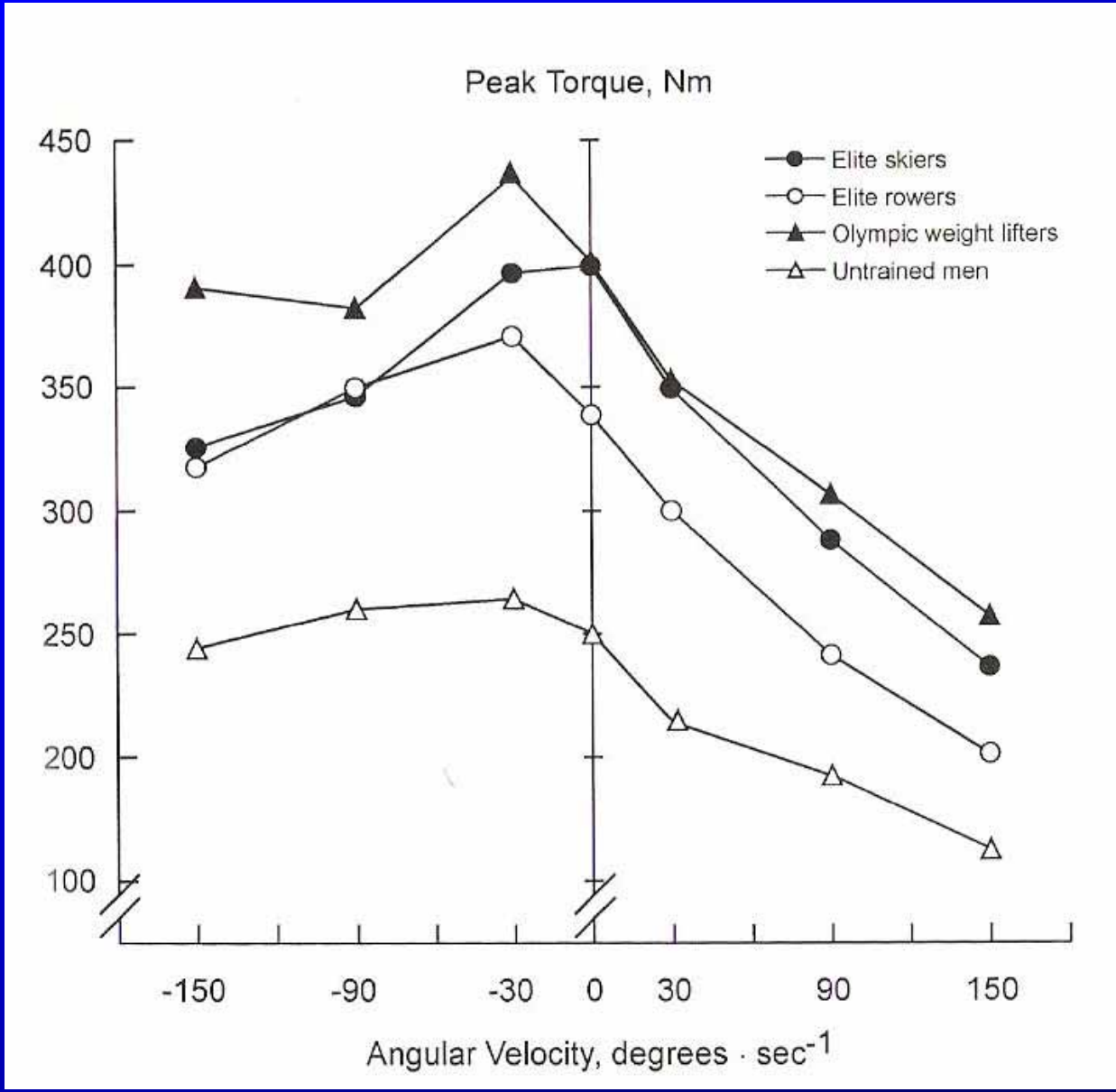
Figur 13

ISOKINETIC STRENGTH IN SKIERS

Mittuniversitetet
MID SWEDEN UNIVERSITY



QUAD TORQUE – VELOCITY RELATIONSHIP IN SKIERS

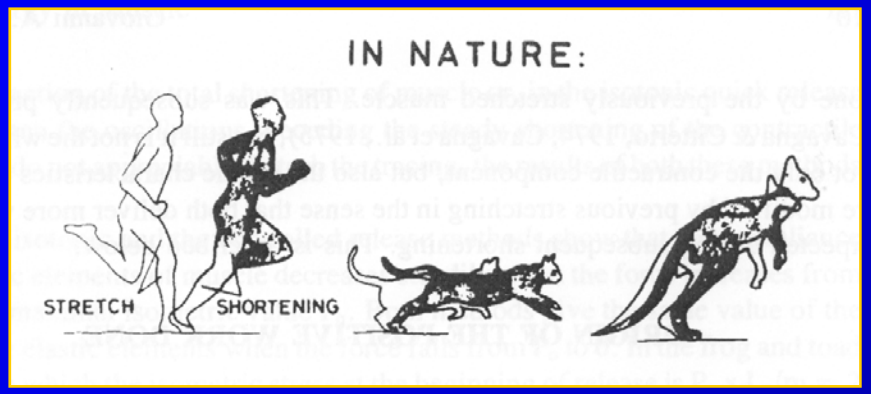


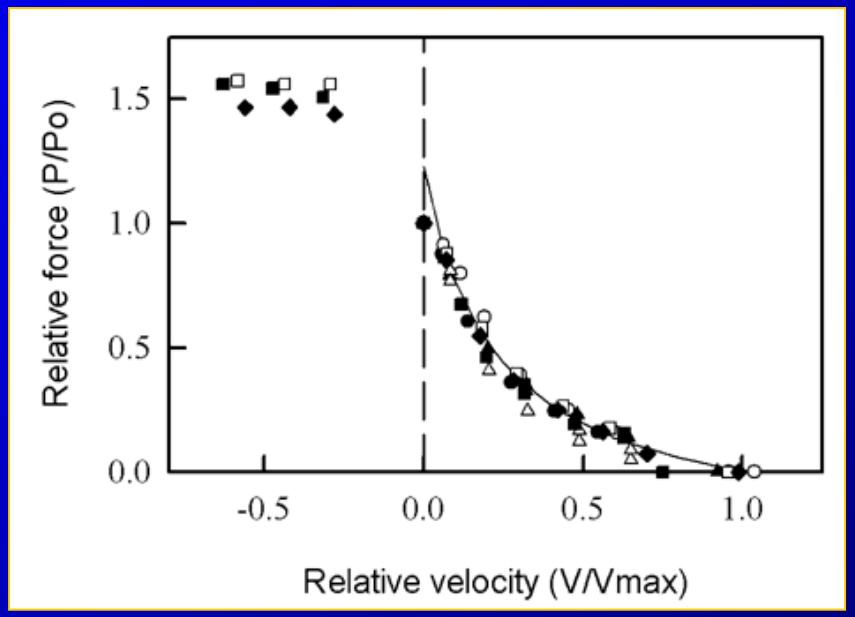
MUSCLE TRAINING FOR SKIING

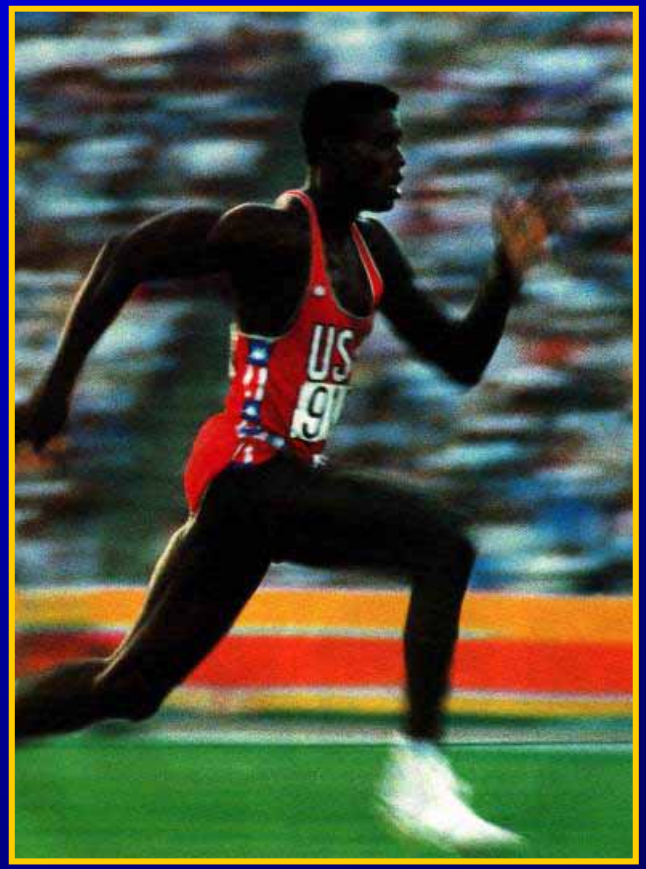
Mittuniversitetet
MID SWEDEN UNIVERSITY

STRETCH-SHORTENING OCCURS IN DAILY LIFE

Mittuniversitetet
MID SWEDEN UNIVERSITY

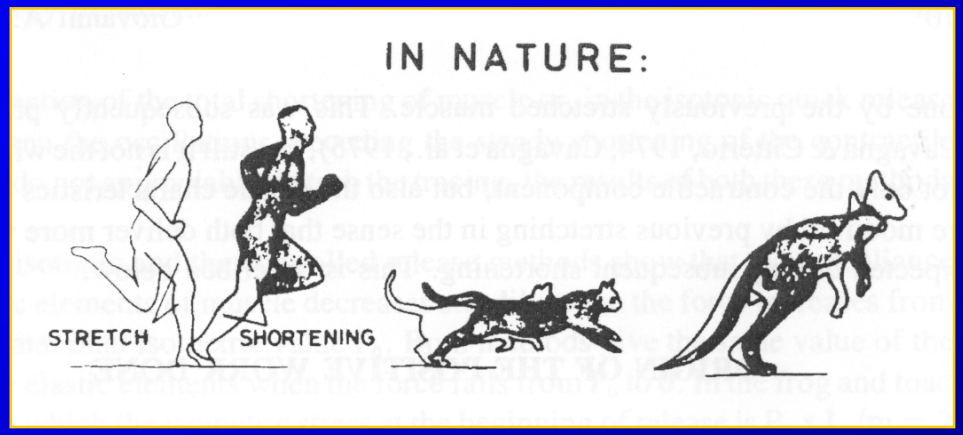




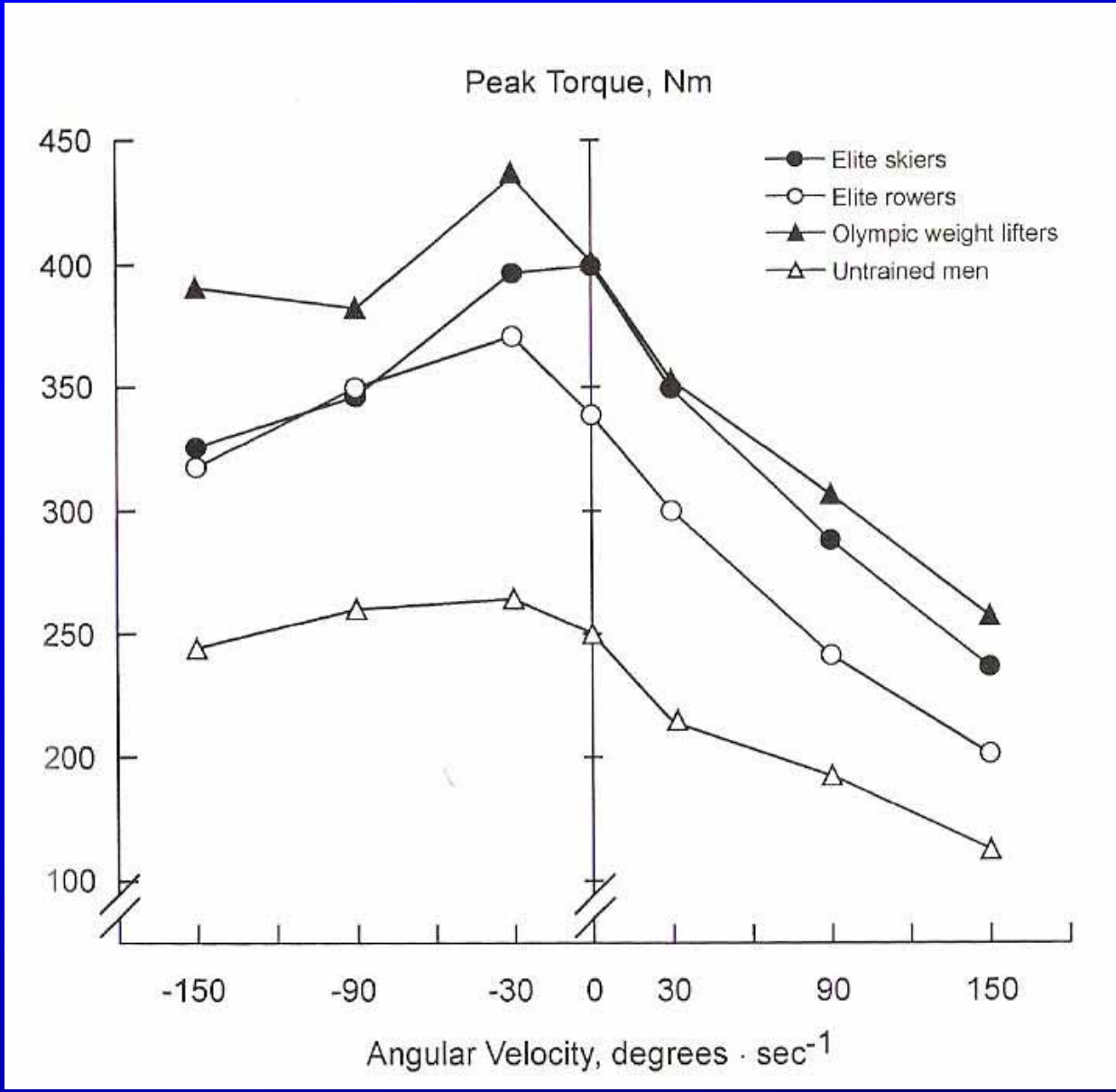


STRETCH-SHORTENING: WHAT ABOUT SKIING?

Mittuniversitetet
MID SWEDEN UNIVERSITY



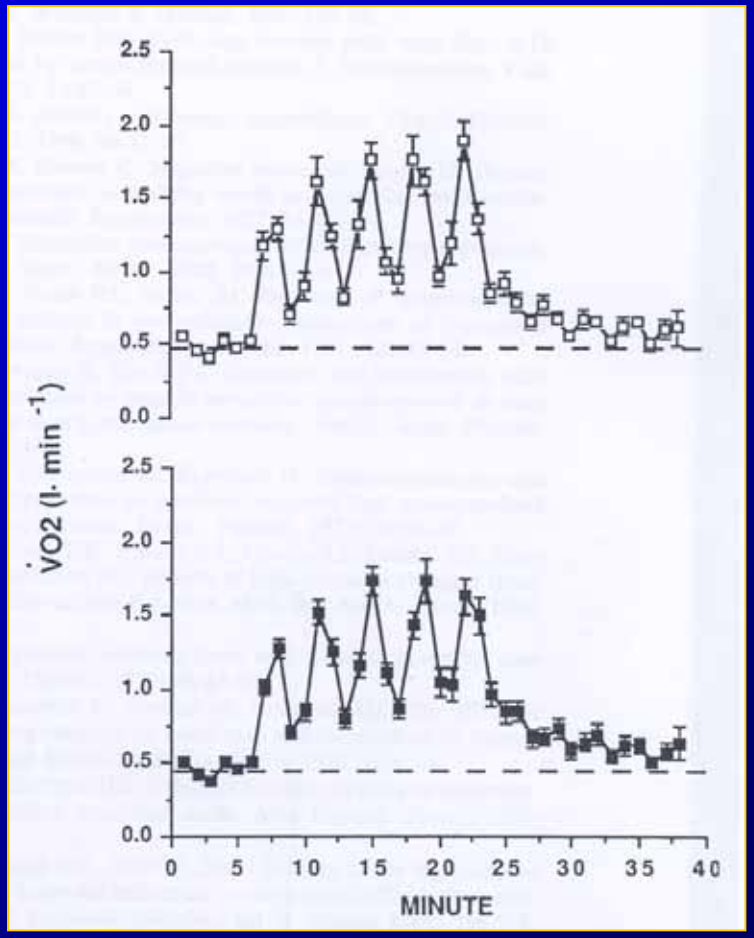
QUAD TORQUE – VELOCITY RELATIONSHIP IN SKIERS



OXYGEN CONSUMPTION DURING ECC AND CON/ECC ACTIONS

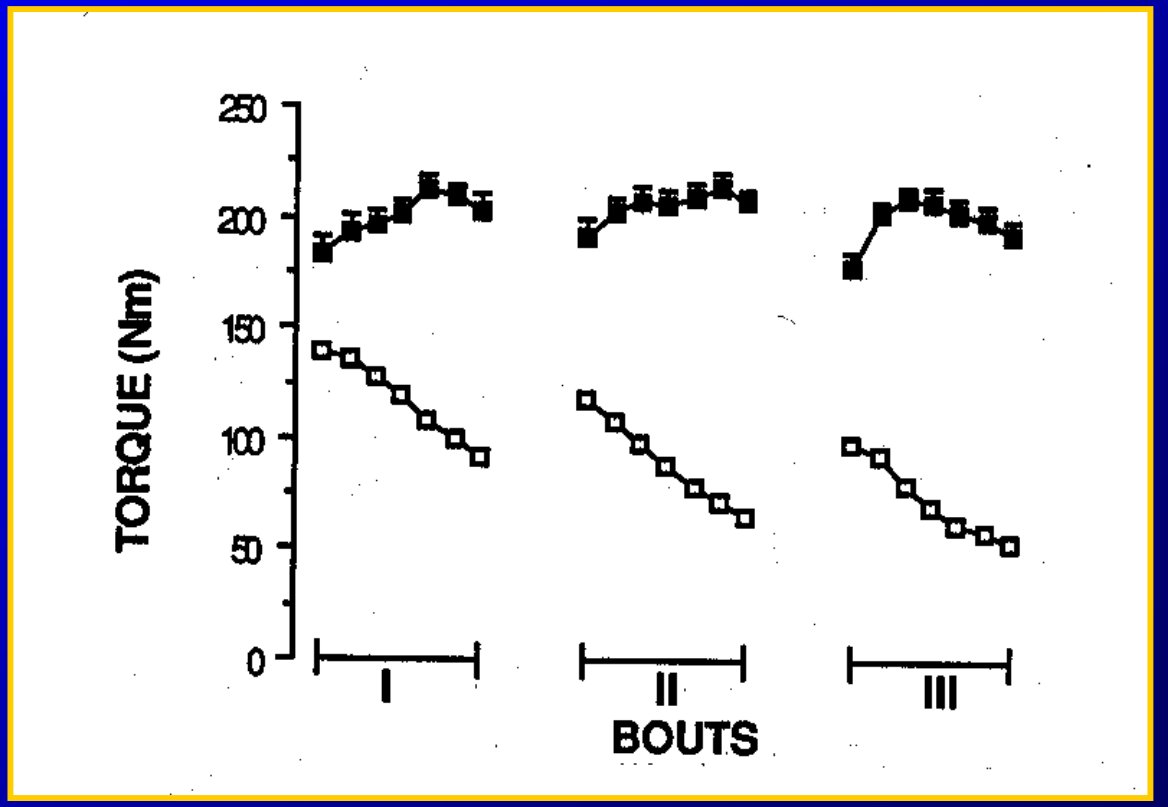
Mittuniversitetet
MID SWEDEN UNIVERSITY

Dudley *et al* 1991



FORCE AND FATIGUE DURING ECC AND CON EXERCISE

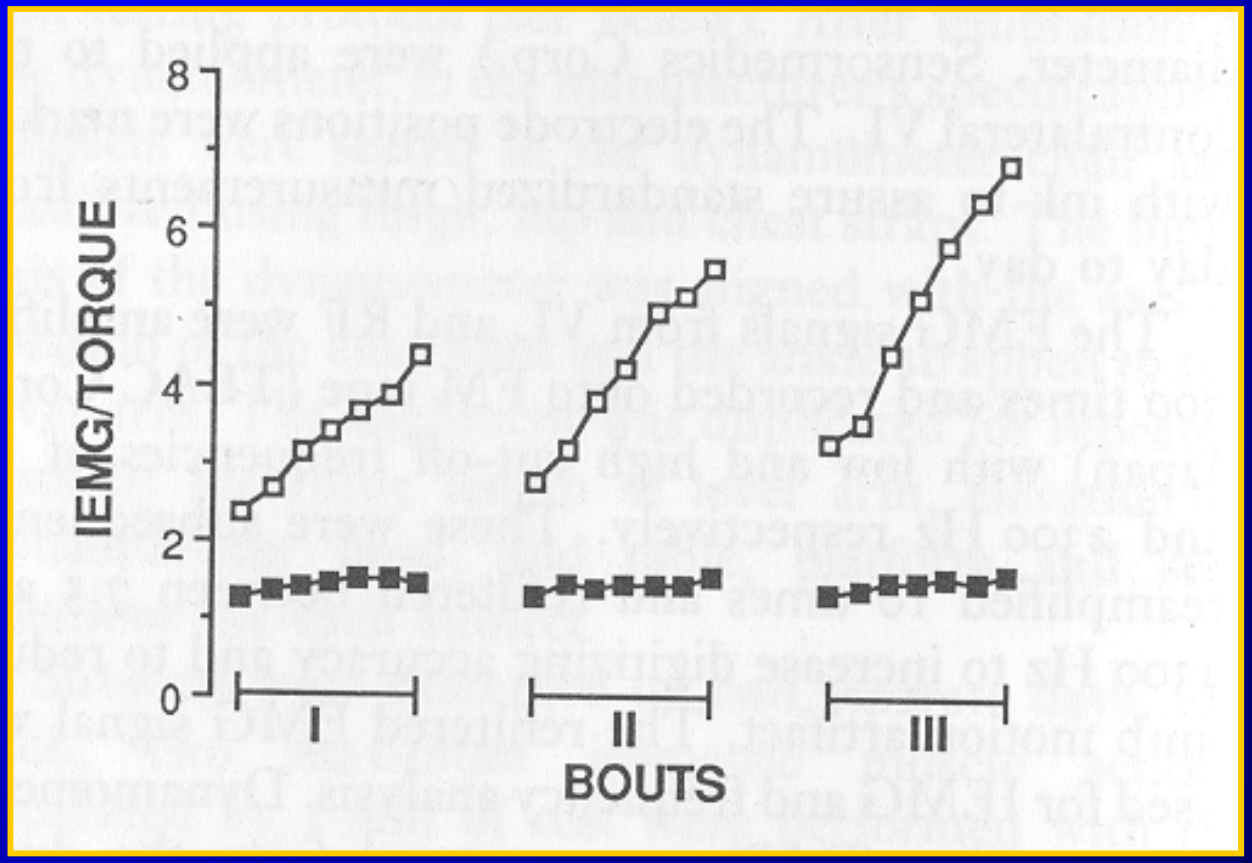
Mittuniversitetet
MID SWEDEN UNIVERSITY



Tesch *et al* 1990

FORCE AND FATIGUE DURING ECC AND CON EXERCISE

Mittuniversitetet
MID SWEDEN UNIVERSITY



Tesch *et al* 1990

FATIGUE IN SKIING

Mittuniversitetet
MID SWEDEN UNIVERSITY

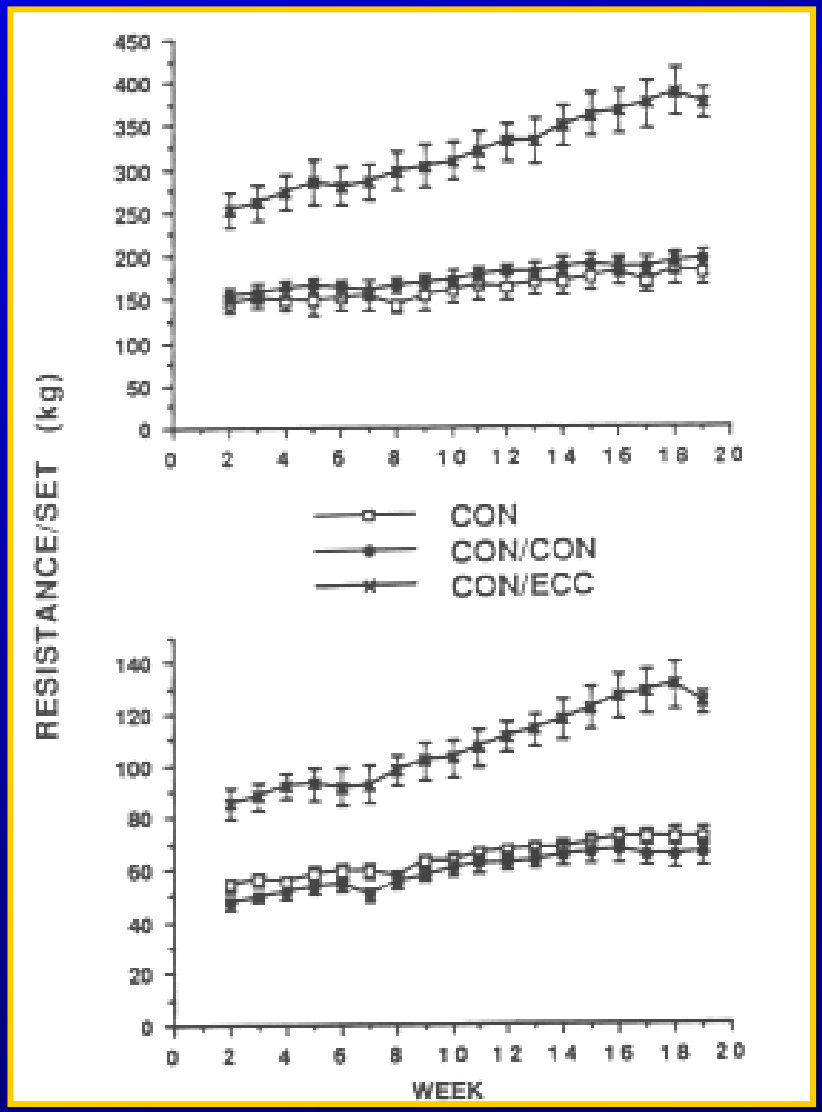
MUSCLE FATIGUE OCCURS MAINLY DURING THE CONCENTRIC ACTIONS NOT THE ECCENTRIC ACTIONS

AS A RESULT THE ECCENTRIC FORCE THAT COULD BE GENERATED WILL BE LESS, AND HENCE PERFORMANCE COMPROMISED

SIDE NOTE: GIVEN THE HEAVY RELIANCE ON ECCENTRIC ACTIONS, THE HIGH OXYGEN UPTAKE DURING SKIING IS, RATHER REMARKABLE!

EFFECTS OF 19-WK ECC/CON VS CON TRAINING

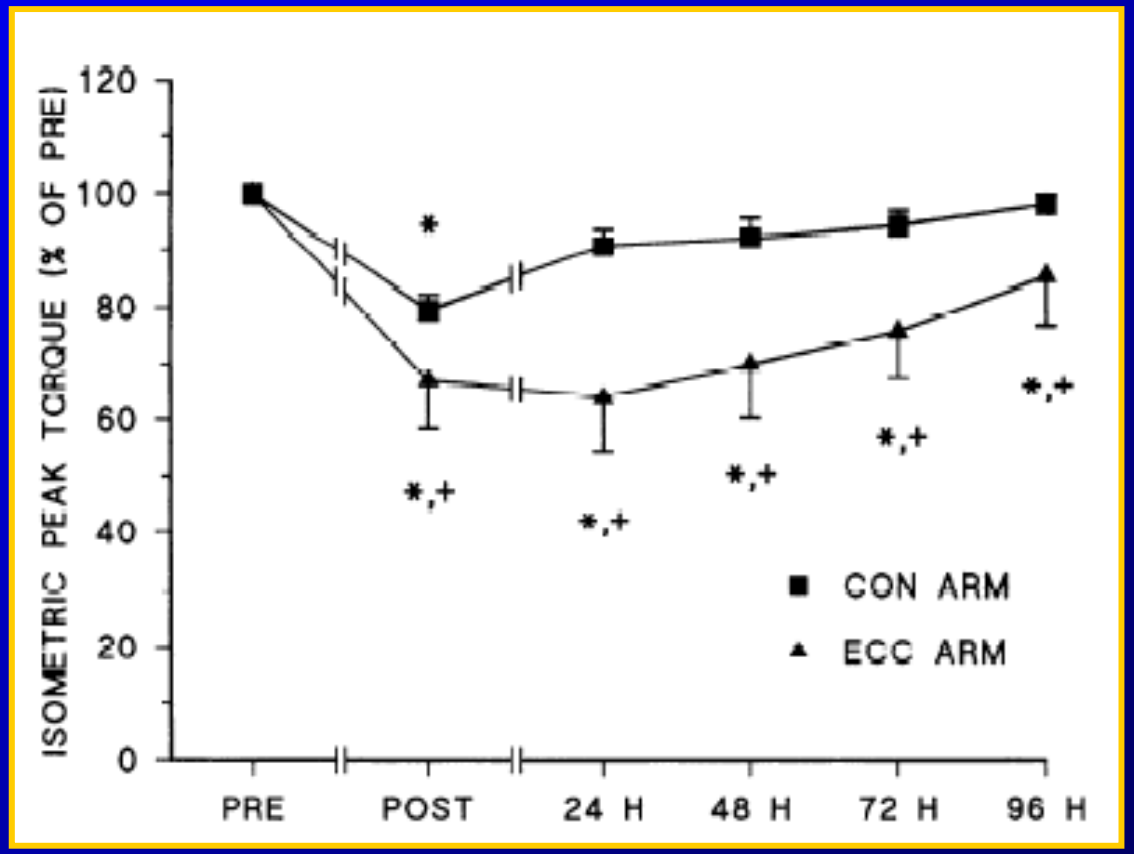
Mittuniversitetet
MID SWEDEN UNIVERSITY



Dudley *et al* 1991

ECC TRAINING MAY REQUIRE LONGER RECOVERY

Mittuniversitetet
MID SWEDEN UNIVERSITY

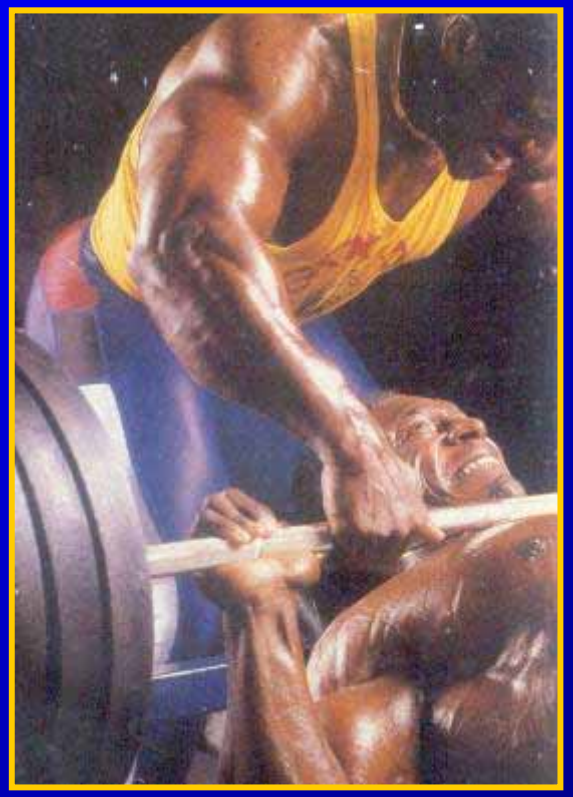


Gibala *et al* 1995

WHAT IS ”ECCENTRIC RESISTANCE TRAINING?

Mittuniversitetet
MID SWEDEN UNIVERSITY

Coupled concentric & eccentric actions with eccentric overload



Plyometric actions

CONCENTRIC AND ECCENTRIC ACTIONS IN SPORTS

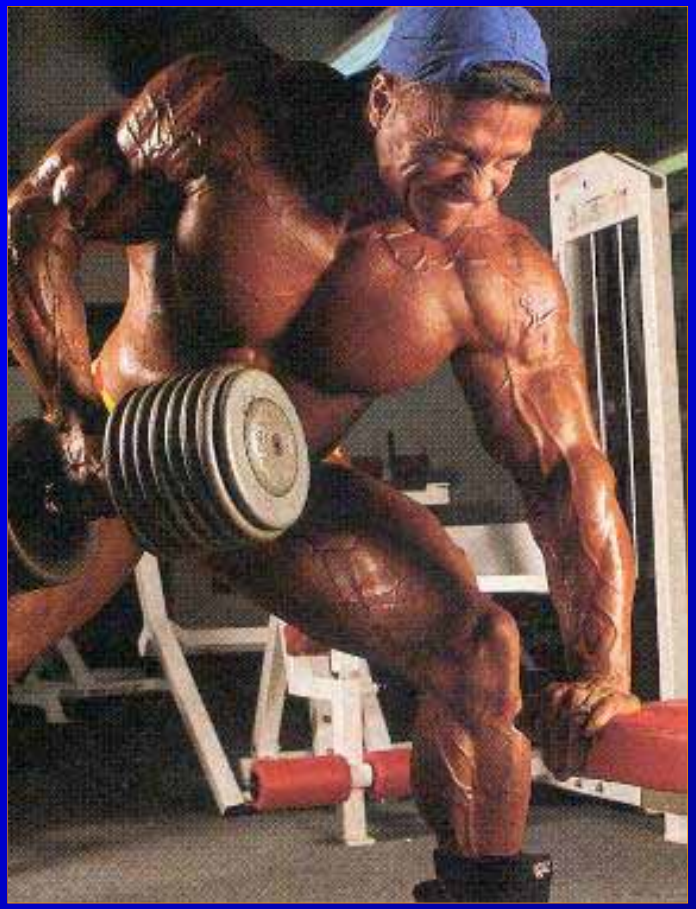
Mittuniversitetet
MID SWEDEN UNIVERSITY

Josefa Idem

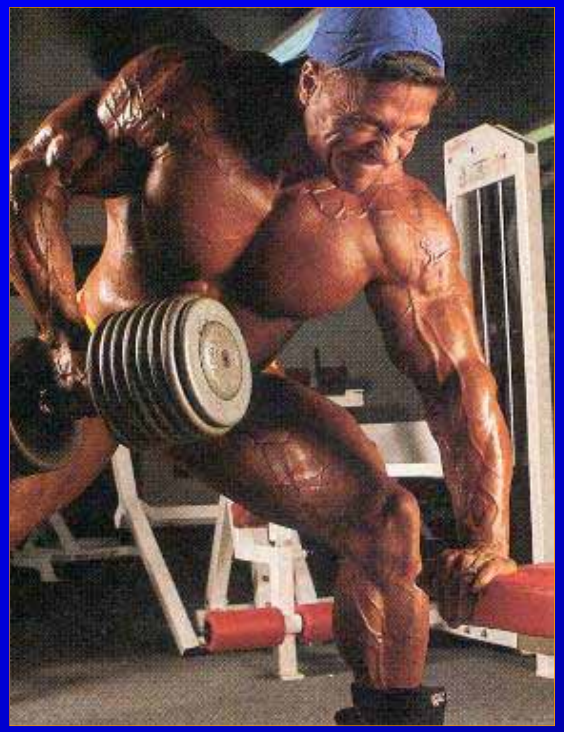

Fredrik Nyberg

OFF SNOW TRAINING IN THE 60's

CONCURRENT TRAINING FOR STRENGTH AND ENDURANCE



CONCURRENT TRAINING: TRADE OFFS IN SKIING



STRENGTH TRAINING INDUCED HYPERTROPHY MAY COMPROMISE:

1. MUSCLE ENDURANCE
2. FLEXIBILITY AND MOVEMENT

CONCURRENT TRAINING: TRADE OFFS IN SKIING

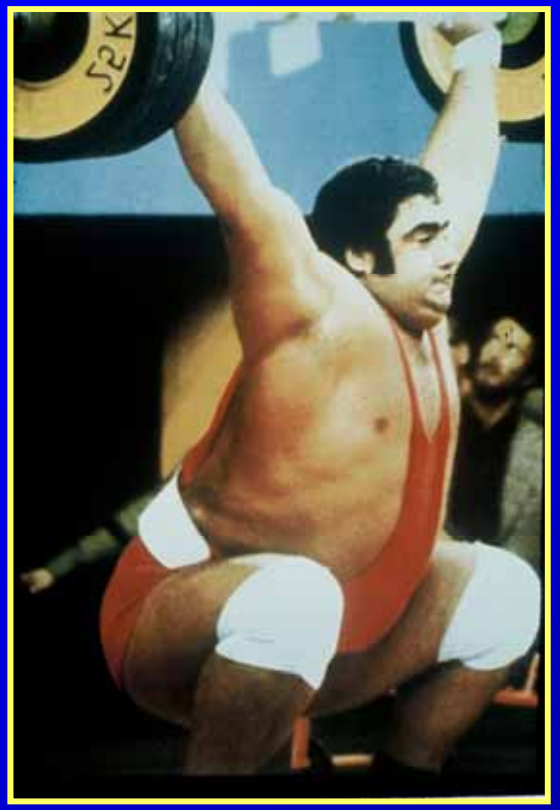
ENDURANCE TRAINING MAY COMPROMISE SPEED AND HIGH VELOCITY FORCE

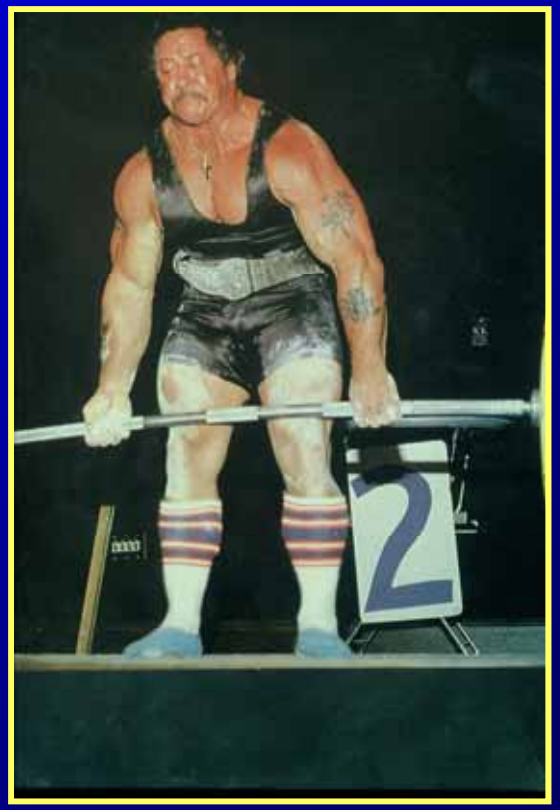
ANAEROBIC TRAINING: TRADE OFFS IN SKIING

EXCESS ANAEROBIC TRAINING MAY COMPROMISE ENDURANCE

TRAINING FOR MASS, STRENGTH OR POWER?

Mittuniversitetet
MID SWEDEN UNIVERSITY





TRAINING FOR MASS-CARRY OVER TO SKI PERFORMANCE?

EL GIMNASIO DE LAS ESTRELLAS

BICEP CURL WITH FLYWHEEL DEVICE

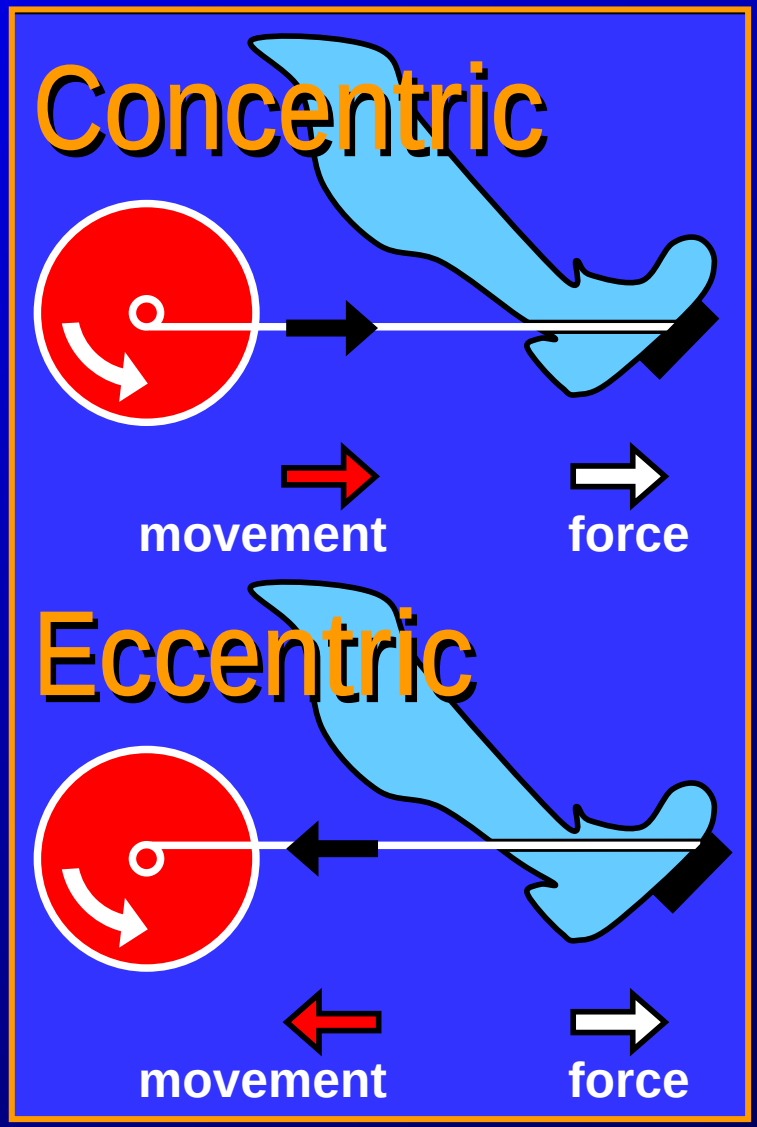
Mittuniversitetet
MID SWEDEN UNIVERSITY

FLYWHEEL RESISTANCE TRAINING

FLYWHEEL: HOW IT WORKS

A *concentric* muscle action accelerates the flywheel against its inertia. A subsequent *eccentric* action is required to decelerate the wheel

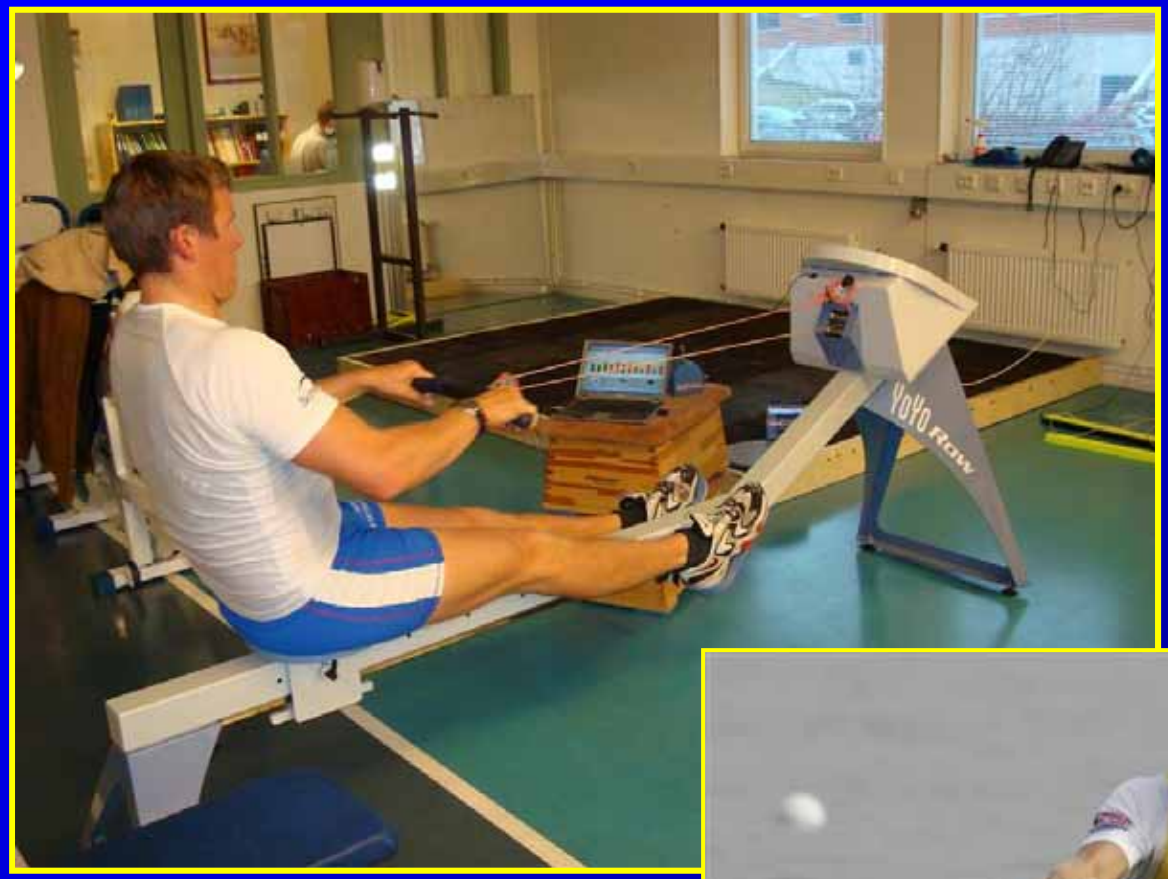
If desired, and depending on strategy, increased load could be generated during the eccentric action (*eccentric overload*)



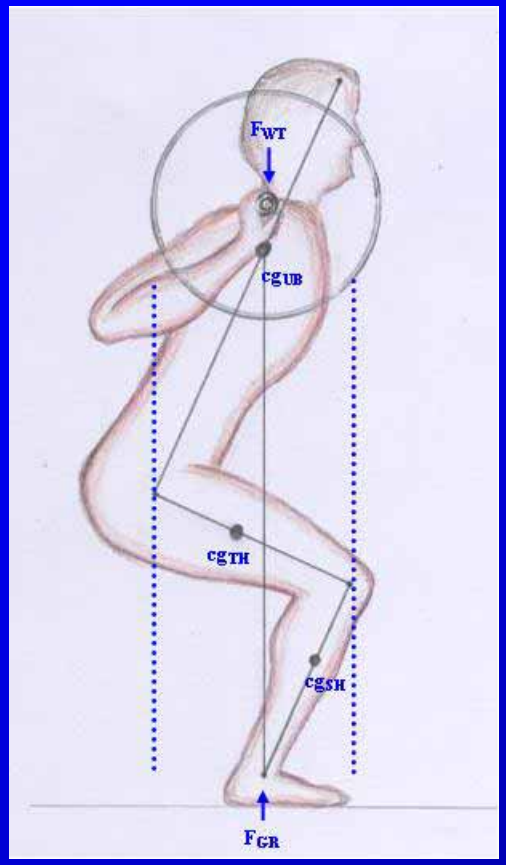
90 D BED REST – FLYWHEEL SQUAT TRAINING

APPLICATIONS IN SPORT

LASSI KARONEN, OLYMPIC FINALIST, BEIJING 2008

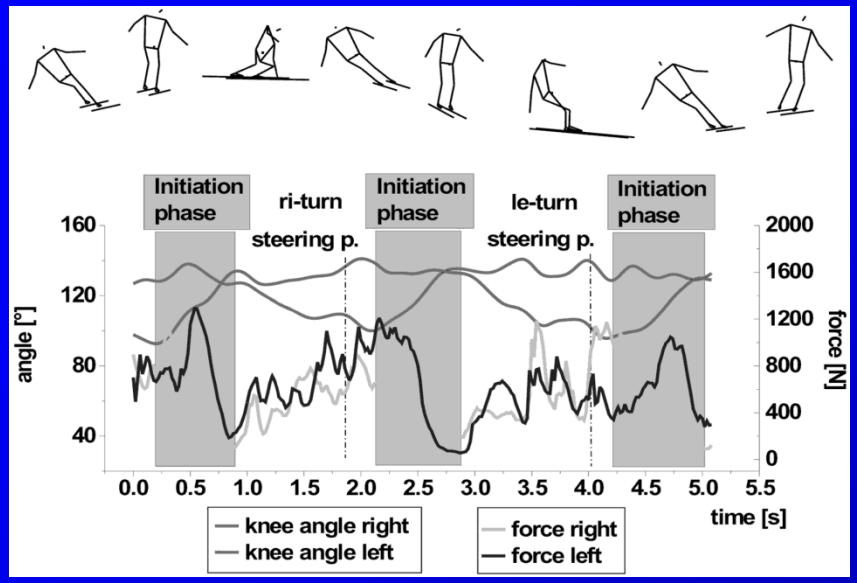


SIMULATING KINEMATICS AND KINETICS IN SKIING

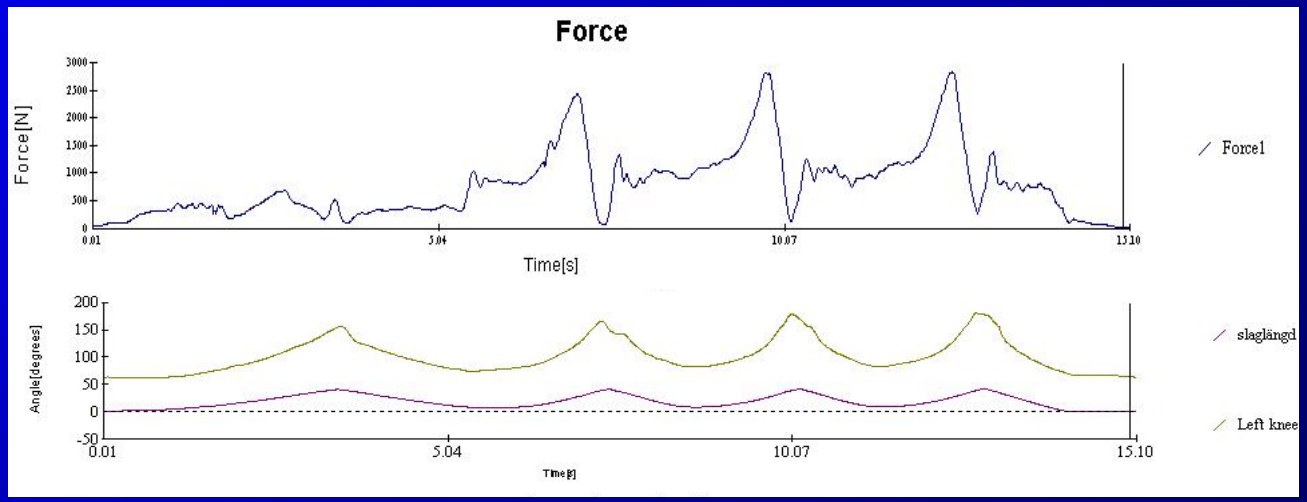


Forces and direction of forces
Knee angles
Duration of concentric and eccentric actions
Upper body position
Lateral actions
Initiation of force

FORCES IN ALPINE SKIING



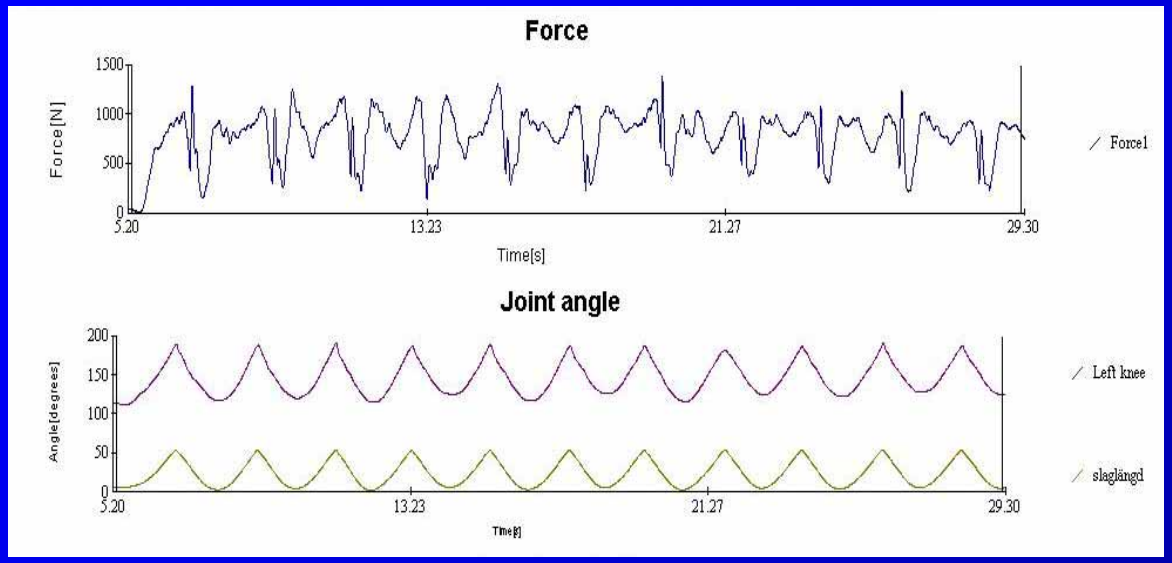
MÜLLER & SCHWAMEDER. Biomechanical aspects of new techniques in alpine skiing and ski-jumping, ***Journal of Sport Sciences*****, 2003, 21, 679-692**



- Force measured with *SENSY 2712* force gauge
- Kinematics measured with goniometers and linear encoders
- Experienced skiers
  - Swedish national alpine team
  - Ski University, Östersund
  - Members of international free ride teams
  - Professional ski instructors
- Different harnesses
  - Body harness
  - Waist harness

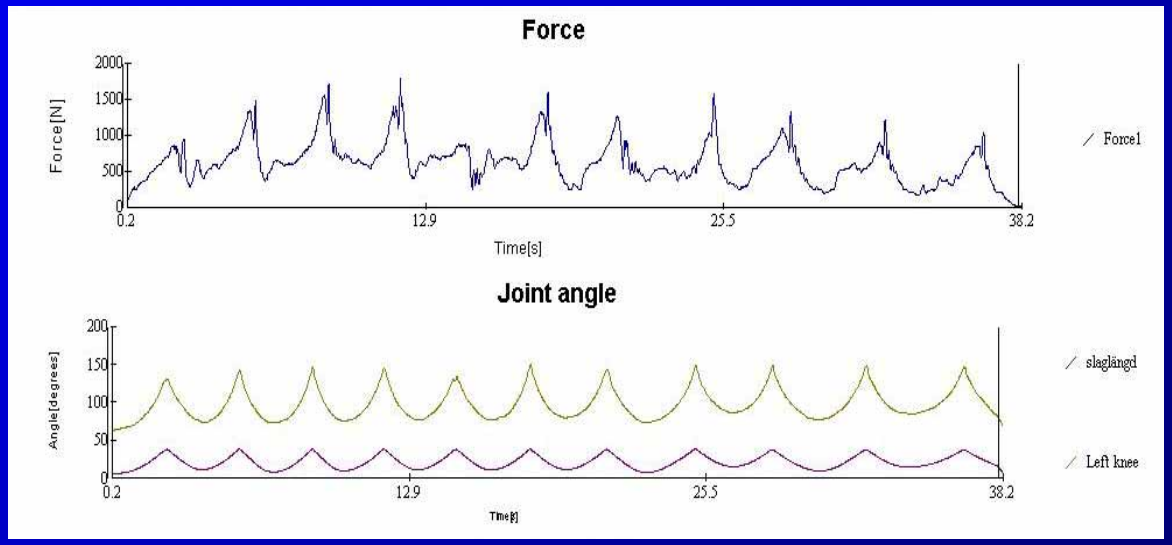
Swaren & Tesch, unpublished material

FORCE IN THE FW SQUAT: EFFECT OF HARNESS



Body Harness

Mean force: 2711 N
Mean knee angle: 134.5 °
Mean displacement: 52 cm



Waist Harness

Mean force: 1988 N
Mean knee angle: 108,9 °
Mean displacement: 36 cm

SQUATTING FOR ALPINE SKIING

TASK SPECIFIC

UNILATERAL

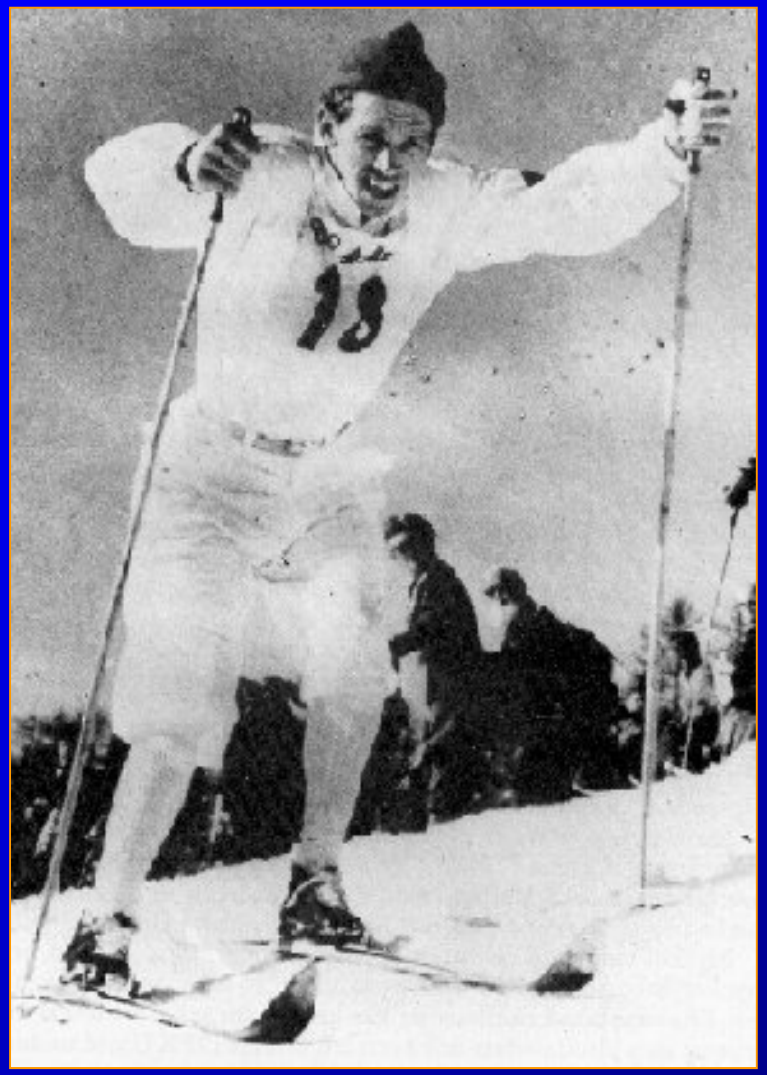
NON-ISOKINETIC; CONTROLLING SPEED

TASK SPEED SPECIFIC; eg., SLOW

STRETCH-SHORTENING

ECCENTRIC OVERLOAD

MARTIN LUNDSTRÖM (BD 1918) S:T MORITZ 1948: 2 GOULDS



MARTIN LUNDSTRÖM: NOV 2009