



INTRODUCTION TO SPORT PHYSIOLOGY AND TRAINING PRINCIPLES

USSA Coaches Education Presentation

Level 300 Mammoth Mountain

2012

J. Stielow, MSc, CSCS, USAW

INTRODUCTION

- Sport consists of preparation and performance
- It's important to make the most effective use of preparation time
- You need to know this stuff!!!
 - Assess if training programs are providing the right stimulus
 - Training needs to target the different power systems (specificity)

Athletic development is the process of evaluating and training all the components of athleticism according to the demands of the sport and the qualities of the individual athlete. It is based on the understanding that athleticism is the ability to perform athletic movements (run, jump, and throw for example) at optimal speed with precision, style, and grace.

OBJECTIVES

- Overview of Sport Physiology
- Energy systems
- Principles of strength training
- Physiological demands of alpine skiing

SPORT PHYSIOLOGY



Immediate Effects of Training

- Increased heart rate (HR)
- Increase respiration rate (RR)
- Increased body temp

Long-term Effects of Training

- Systematic training leads to adaptations in:
 - Muscles
 - Energy pathways
 - Cardiovascular system
 - Respiratory system

The discipline involving the examination of how physical activity or sport influences the structure and function of the human body.

BIOLOGICAL ENERGY SYSTEMS

- **ATP-CP (The Phosphagen System):** provides ATP for short-term, high intensity activities and is active at the start of all exercise regardless of intensity.
 - Resistance training
 - Sprinting
 - **Anaerobic or Lactic Acid:** the breakdown of carbohydrate (CHO) either glycogen stored in the muscle or glucose delivered in the blood to resynthesize ATP. It involves multiple enzymatically catalyzed reactions.
 - **Aerobic glycolytic and aerobic lipolytic (fat) system:** the primary source of ATP at rest and during low intensity activities, uses primarily CHO and fats as substrates.
-

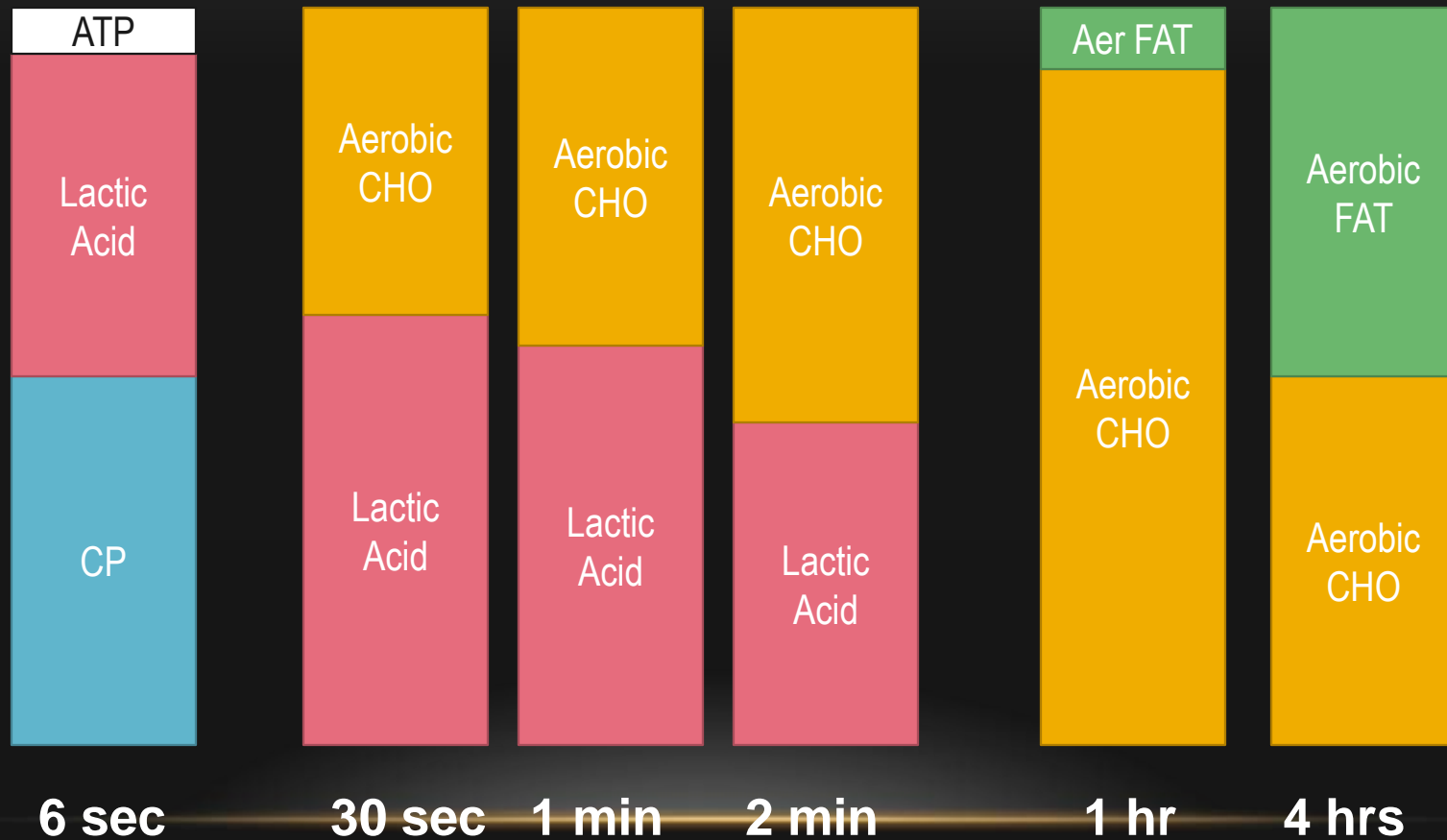
ENERGY SOURCES

- **Adenosine triphosphate (ATP)**: the energy currency used by muscle cells to allow them to produce force and is broken down into ADP.
- **Creatine Phosphate (CP)**: a high energy phosphate molecule found in muscle cells which is an immediate source of reformatting ATP from ADP ($ADP + CP = ATP$).
- **Lactic Acid (LA)**: a fatiguing metabolite of the lactic acid system resulting from the incomplete breakdown of glucose during muscle contraction that can be reused to produce ATP.
- **Muscle glycogen**: the storage form of carbohydrate, made of glucose molecules.
 - Can be rapidly broken down to produce ATP for intense exercise or more slowly for endurance type exercise.

ENERGY SOURCES

Substrate	Value	% Body Content	Net Wt.	Energy
Muscle glycogen	4.0 kcal/g	10g/kg x 70kg x 0.4	280g	1120 kcal
Liver glycogen	4.0 kcal/g	50g/kg x 2kg	100g	400 kcal
Blood Glucose	4.0 kcal/g	100mg/dl x 5L	5g	20 kcal
Extracellular glucose	4.0 kcal/g	100mg/dl x 12L	12g	48 kcal
Fat	9.3 kcal/g	70kg x 0.10	7000g	65,100 kcal
Protein	4.1 kcal/g	70kg x 0.14 x 0.3	2940g	12,500 kcal

WHAT FUELS YOUR SPORT?



LACTIC ACID – AN ENERGY SOURCE?

- Produced during anaerobic effort, or when O₂ supply is limited.
- Accumulates in the muscle and can affect its ability to perform.
 - Increased H⁺ ion concentration reduces enzyme activity and ATP production and contractile force of the muscle fiber.
- **News flash!!!**
 - The muscle cell can reuse lactate
 - Lactate is burned inside the mitochondria (cells powerhouse)
 - Endurance training has been shown to reduce blood levels of lactate, even while cells continue to produce same amount of lactate (Brooks, 2000).

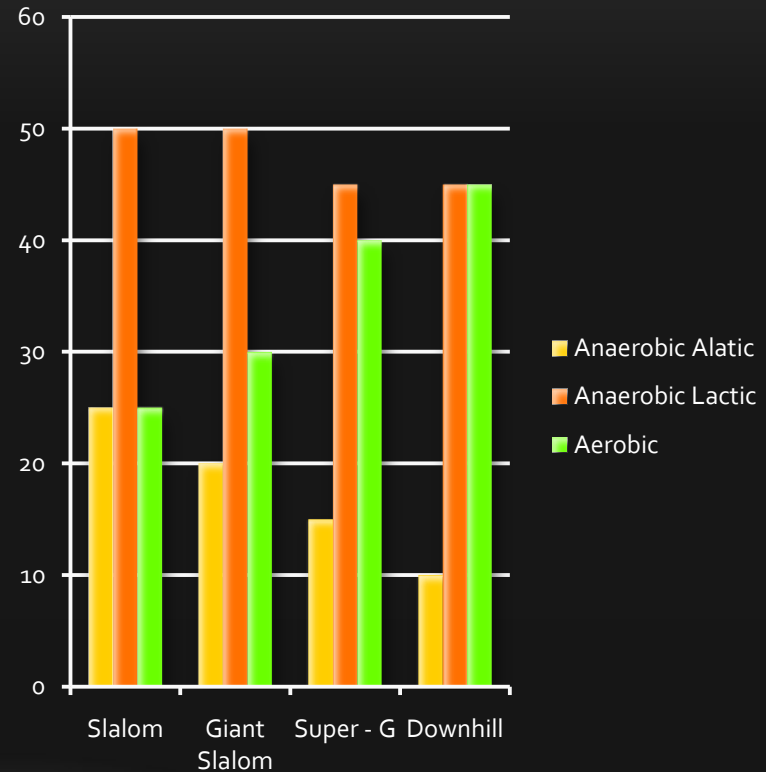
WHY AEROBIC TRAINING IN AN ANAEROBIC SPORT?

- Train to train
- Base allows you to complete the anaerobic training successfully
 - Increases Quality of training
- Recovery between runs
- Altitude and daily travel
- Target weaknesses

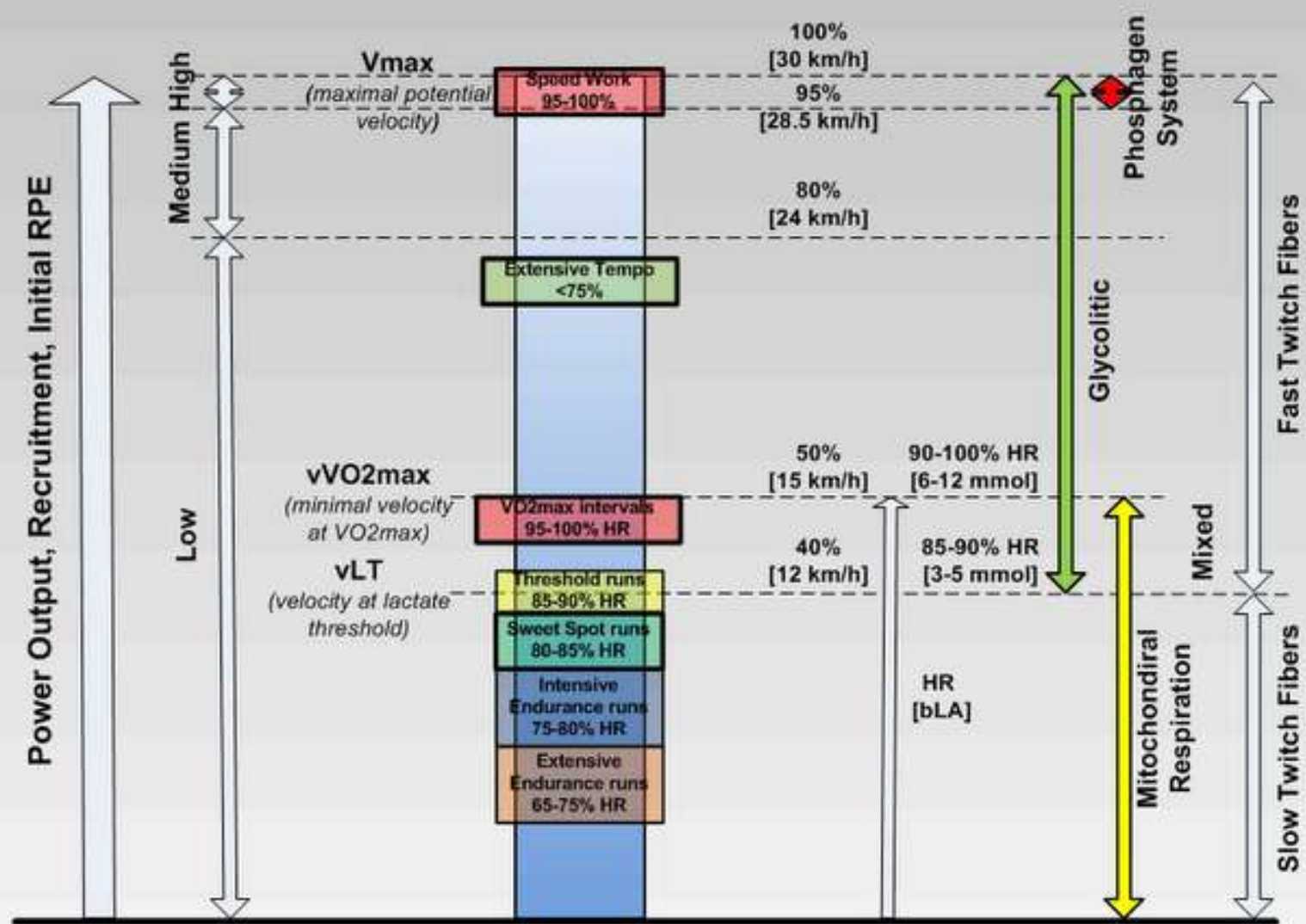
ENERGY SYSTEM CONTRIBUTION IN ALPINE SKIING

Generally classified as anaerobic

- Requires contribution from all energy systems (16, 34, 37).
- Elite skiers tax 95 – 120% of aerobic capacity during GS (20).
- Max VO_2 ranges for men are 51.4 to 53.4 ml.kg⁻¹.min
- Max VO_2 ranges for females are 43.4 to 46.7 ml.kg⁻¹.min
- The highest value for alpine skiing is about 70 ml.kg.min



Energy System Continuum



PHYSIOLOGY OF MUSCLES



MUSCLE FIBER TYPES

C h a r a c t e r i s t i c o f M u s c l e F i b e r s			
Characteristics	Slow Twitch	Fast Twitch	
	Slow Oxidative (SO)	(FOG) Fast-oxidative glycolytic	Fast-glycolytic
Avg. Fiber %	50	35	15
Speed of Contraction	Slow	Fast	Fast
Time to peak tension (s)	0.12 sec	0.08 sec	0.08 sec
Force of Contraction	Lower	High	High
Size	Smaller	Medium	Large
Fatigability	Fatigue resistant	Less resistant	Easily fatigued
Aerobic Capacity	High	Medium	Low
Capillary density	High	High	Low
Anaerobic capacity	Low	Medium	High

ALPINE SKIING MUSCLE PHYSIOLOGY

- Alpine skiers do not show a distinct fiber type (42).
 - Preponderance to Type I fibers vs. Type II fibers.
- “Allalin 2000” study conducted by Vogt et al. (50).
 - Reduction in glycogen was higher in Type I vs. Type II fibers
 - Carbohydrate metabolism (51).
 - 64.6% Type I fibers
 - 35.4% Type II fibers
- Preferential reliance on Type I in highly skilled skiers is necessary for sustained near maximal contractions at low angular velocities (8).

GENES VS. TRAINING

Genes

- We all inherit a certain % of SO and FG fibers
- Elite distance runners have higher percentages of SO fibers.
- Sprinters and high jumpers have higher percentages of FG fibers.



Training

- The way the fibers are used also influences the % of each type.
- Fibers respond to demands placed on them.
- Resistance training causes increase in muscle hypertrophy.
- SO, FOG, and FG fibers respond to endurance training by increasing ability to use oxygen and resist fatigue.

COMPONENTS OF MUSCULAR FITNESS



- Strength
- Power
- Muscular endurance
- Reaction time
 - Quickness
 - Speed
- Balance
- Flexibility
- Agility

STRENGTH

- The maximal force that can be exerted in a single effort.
- Directly related to cross-sectional area of a muscle.
- Resistance training can increase the number of fibers recruited for work.
 - Training increases the cross sectional area by increasing contractile proteins and thus strength.



POWER



- Defined as the rate of doing work
- Strength multiplied by velocity.
- **Key:**
 - Athletes must be strong enough to generate necessary power for success.
 - Once athletes have adequate strength, they must use that strength at the velocities necessary in competition.

ELASTIC RECOIL (STRETCH – SHORTENING CYCLE)



- Involved in running, jumping, throwing, striking.
- Uses stored energy potential that results from the quick stretch followed by a shortening contraction.
- Potential energy is caused by elastic energy in the muscle fibers resulting from stretching of the cross bridges in muscle proteins, activation of stretch reflexes and the muscle protein elastin.
- Mostly used in plyometric activities.

PLYOMETRICS

- Running and jumping incorporate the stretch shortening cycle.... So does hop scotch!
- Kids do it anyway...
- Super focused on technique
- Low volumes!!!



ENDURANCE

Muscular Endurance

- Ability to sustain submaximal contractions.
- Achieved in sport specific training.
- Usually involves small muscle groups.

Power Endurance

- Ability to repeatedly perform a skill with adequate speed.
- The number of reps within a time limit.

STRENGTH-ENDURANCE CONTINUUM

The Strength–Endurance Continuum

			Power endurance		
	Strength	Power	Short-term (anaerobic) endurance	Intermediate endurance	Long-term endurance
Force	Maximal force	Explosive force	Brief (2-3 min) persistence with heavy load	Persistence with intermediate load	Persistence with lighter load
Prescription	2-8RM 1-3 sets	5-15RM 1-4 sets	10-25RM 3 sets	30-50RM 2 sets	Over 100RM 1 set
Improves	Contractile protein (actin and myosin) ATP and PCr Connective tissue	Strength and speed of contraction ATP and PCr Connective tissue	Some strength and glycolytic metabolism (glycolysis)	Some endurance and anaerobic metabolism Slight improvements in strength for untrained	Aerobic enzymes Mitochondria Oxygen and fat utilization
Doesn't improve	Oxygen uptake, endurance	Oxygen uptake, endurance	Oxygen uptake		Strength and power

RM = Repetition Maximum, or how many repetitions an athlete can do with a given resistance before failure.

ATP = Adenosine Triphosphate

PCr = Phosphocreatine

Adapted, by permission, from B.J. Sharkey, 2002, *Fitness & Health*, 5th ed. (Champaign, IL: Human Kinetics), 153.

REACTION TIME VS. QUICKNESS

Reaction Time

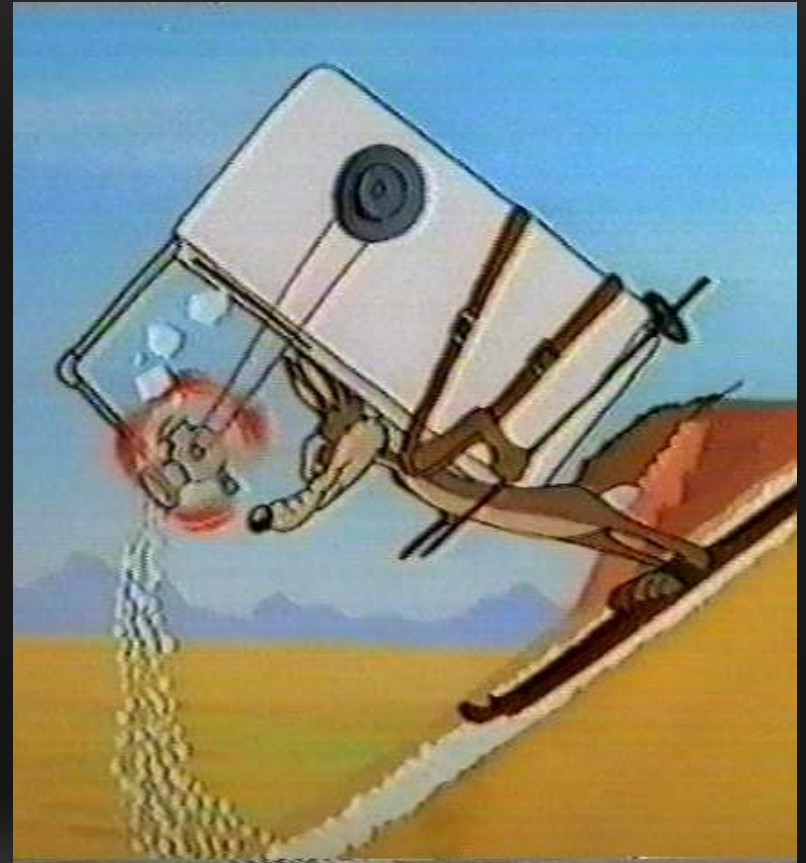
- The time spent processing and signaling
 - Can't really change signaling time, but with experience we can learn to process information more efficiently.
 - Experience plays a large role to improving reaction time (learned).

Quickness

- Refers to both the reaction time to stimuli (genetic and learned) and the speed of his/her initial movements.
- Athletes with high levels of muscular power can accelerate quickly to make appropriate movements within a small area of one or two steps.

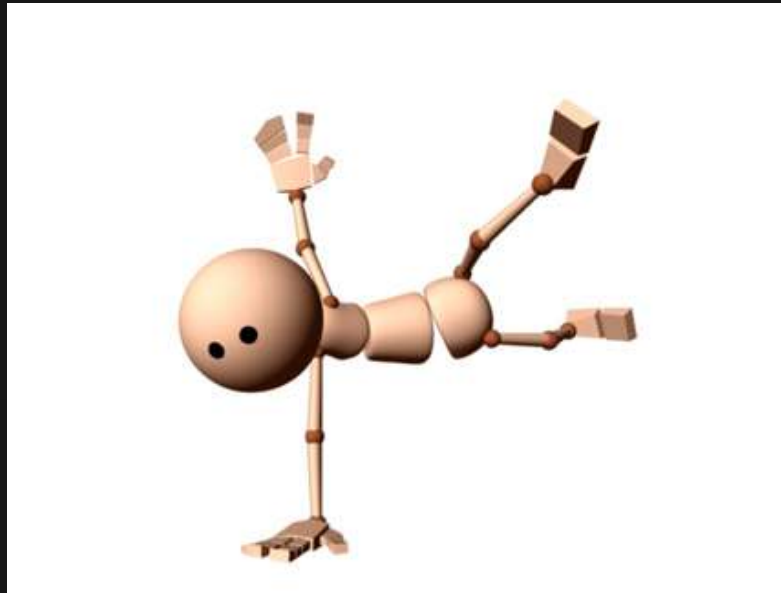
SPEED

- The final product of reaction time and quickness
- Fast = athletes who have good speed are able to attain high velocities once they get moving.
- Example: sprinters are required to have excellent reaction times, quickness, and speed.



BALANCE

- **Dynamic** : ability to maintain equilibrium during vigorous movements
- **Static**: the ability to maintain equilibrium in a stationary position



AGILITY



The ability to change speed and direction rapidly with precision and without loss of balance

Strength
Power, Power endurance
Speed
Quickness
Reaction time
Balance
Flexibility



FLEXIBILITY

- The range of motion that the joints can move through.
- Depends on the joint itself and the associated tendons, muscles, and ligaments.
- Influenced by gender, habitual use, and stretching of the joint associated structures.



IMPORTANT PHYSICAL AND MOTOR ABILITIES FOR ALPINE



TRAINING PRINCIPLES



TRAINING PRINCIPLES

Adaptation

- Athletes must learn and become accustomed to the tasks and activities they are required to perform in training,
- As well as the conditionings in which these tasks and activities are executed.

Specificity

- Particular tasks or activities
- Performed in particular conditions
- Leads to particular adaptations
- They are not necessarily transferable to other tasks or conditions.

TRAINING PRINCIPLES

Overload

- The nature, intensity, duration, and frequency of the training tasks or activities must represent an adequate challenge for the athlete, and force him or her to produce an effort.

Individuality

- Demands of activity or task must be adapted to the capabilities of the athlete to induce the desired training and learning effects.

Reversibility: The adaptations achieved through physical activity are reversible.

TRAINING PRINCIPLES

Progression

- Overload or challenge must be introduced in a progressive and logical fashion over time.
- Simple to complex
- Part to whole
- Easy to more difficult

Purpose

- Must have a clear purpose to achieve desired training or learning effects.
- Purpose determines the best activities, methods, and conditions to use in the practice.
- Participants must also know and understand the purpose of the exercise when they go to perform the task.

WARMING UP

- First, do a general warm-up of 5 to 10 minutes of light movement, such as jogging or riding a bicycle, to prepare for exercise.
- Then do a specific warm-up using movements similar to those you'll do in your more strenuous exercise session (e.g., if you will perform a biceps curl, do an initial set of biceps curls with little to no weight).

COOLING DOWN

- A cool-down after working out is important so that blood doesn't pool in your extremities, which could temporarily disrupt blood flow and deprive the heart and brain of oxygen.
- Devote 5 to 10 minutes to stretching, walking, or continuing your workout activity at a slower pace to cool down the body.

DON'T FORGET RECOVERY!!!

- The body must recover from the fatigue that results from the training activities, otherwise progression may be impaired.
- Active
- Passive
- Rest (sleep)
- Nutrition



WHAT HAPPENED TO REST?

In *Science and Skiing II* (2001), Hanin stated,

"The predominant emphasis in elite sport is on the volume and intensity of work loadings. Typically, the recovery is seldom systematically related to the amount of work done...athletes and coaches do not perceive recovery as an integral part of the performance process."

KEY CONCEPTS RESISTANCE TRAINING

Muscle Balance

- Must maintain balance in strength between opposing muscles.
- Each sport has primary movers – muscles

Repetition Maximum

- The number of times an athlete can lift a load before exhaustion.
 - If an athlete can lift a weight 10 times before failing (10RM)
 - Many books and articles define resistance training using % maximum strength (% max)
 - 5RM lift ~ 85%max
 - 10RM lift ~ 70%max

SETS, REPS, CIRCUITS, ETC....

- **Rep** one complete cycle of an exercise (1 crunch)
- **Set** the number of reps completed continuously without a rest period (30 crunches)
- **Circuit training** a method of putting sets of exercises together such that an athlete does one set of exercises before repeating sets
- **Set-rep training:** organizes into multiple repeated sets of one exercise before the next exercise (3 sets of 10 crunches then 2 sets of 10 squats).
- **Rest period:** refers to amount of time allotted for recovery between sets

FITT PRINCIPLE

- **Frequency:** How often you do physical activity in a week
 - **Intensity:** How hard you work while you're performing the activity
 - **Time:** How long you do the activity
 - **Type:** What type of activity you do
-

ORGANIZING A TRAINING PROGRAM

- **Goals and Needs Assessment** – you must measure in order to manage
 - Physical fitness assessments need to be completed multiple times per year and records should be kept to assist in planning.
- **Core Stability** – related to strength, dynamic balance, coordination and balance among core muscle groups.
 - Focus in prep period to increase athletes ability to stabilize the abdomen, back, and shoulder muscles of athletes to increase gains later in the programming.

EXERCISE ORDER

- Begin all training with light **warm-up** sets for all muscle groups trained.
 - Warm up allows the body to adjust physiologically, neurologically – prepares the body to perform the upcoming tasks.
 - **When training all major muscle groups in a workout:**
 - Train large muscle groups before small muscle groups
 - Perform multiple joint exercises before single joint exercises
 - Perform high intensity exercises before lower intensity exercises
 - **Remember to cool down from training**
-

OPTIMAL ORDER OF ACTIVITIES

Early in Main Part of Practice

Activities to acquire new techniques, skills, or motor patterns

Activities that develop or require coordination or balance

Activities that develop or require speed

Then Consider.....

Activities to develop or require speed-endurance

Activities to develop or require strength

Activities to develop or require strength-endurance

Later in Main Part of the Practice.....

Athletes may be fatigued, so try to plan for:

Activities that consolidate skills already acquired

Activities that develop or require strength

Activities to develop or require strength-endurance

FREQUENCY

- How often you train specific muscle groups or energy systems depends on:
 - Goals
 - Fitness level
 - Age and Gender (where are they biologically)
 - Intensity of training
 - Ability to RECOVER

WHEN DO YOU START?

Foundation Stage		Pre & Post Puberty			World Class Performance Full Maturation
PHASE 1	PHASE 2	PHASE 3	PHASE 4	PHASE 5	PHASE 6
<p>Biological Age Pre Puberty</p> <p>Age 2-6 years old</p> <p>Play Age 1-4 years</p> <p>Participation Ski 1 day a week or less 20 days a year At least 95% free skiing Play 2-4 other sports - gymnastics or balance-based sports</p>	<p>Biological Age Pre Puberty</p> <p>Age 6-10 years old</p> <p>Training Age 1-4 years</p> <p>Participation Ski 2-3 days a week 50 days a year At least 90% free skiing Fun races Play 2-4 other sports</p>	<p>Biological Age Pre Puberty</p> <p>Age Girls: 10-13: J4 (J5-J3) Boys: 11-14: J4 (J4-J3)</p> <p>Training Age 4-8 years</p> <p>Participation Ski 3-4 days a week 70 days/year At least 60% free skiing Competition Period: (Jan-April) Number of race starts: 10-15 Ratio 1:6 (race:training) Play a complementary second sport</p>	<p>Biological Age Puberty (Growth Spurt)</p> <p>Age Girls: 11-14: J3 (J4-J3) Boys: 12-15: J3 (J4-J2)</p> <p>Training Age 5-9 years</p> <p>Participation Ski 4-5 days a week 100 days/year At least 30% free skiing Competition Period: (Dec-April) Number of race starts: 15-30 Ratio 1:5 (race:training) Play a complementary second sport</p>	<p>Biological Age Post Puberty</p> <p>Age Girls: 12-16: J3 (J4-J2) Boys: 14-17: J2 (J3-J1)</p> <p>Training Age 6-11 years</p> <p>Participation Ski 4-5 days a week 120-140 days/year At least 15% free skiing Competition Period: (Nov-April) Number of race starts: 25-max 45 Ratio 1:4 (race:training) Play a complementary second sport</p>	<p>Biological Age Full Maturation</p> <p>Age Female: 16+ J2-J1 Male: 17+ J1</p> <p>Training Age Minimum 10+ years</p> <p>Participation Ski 4-5 days a week 130-150* days/year At least 10% free-skiing Competition Period: (Nov-April) Number of race starts: 55* Ratio 1:3 (race:training) *based on the number of disciplines</p>
Conditioning Emphasis					
<p>Introduction to conditioning through sports participation</p> <p>Play and fun emphasis, skiing, balance sports</p>	<p>Continue multi-sport, active lifestyle</p> <p>Play and fun emphasis, basic agility and balance, coordination</p> <p>Incorporate activities that develop explosiveness (0-10 sec) and general endurance</p>	<p>1-2 dry land sessions per week</p> <p>Further development of previous components. Emphasis on aerobic conditioning. Incorporate own body weight training and body awareness training</p>	<p>1-2 dry land sessions per recovery week</p> <p>Increase aerobic conditioning and balance/agility/coordination, particularly through growth spurt. Begin light external resistance work including bands, med balls, etc.</p>	<p>2-3 dry land sessions per recovery week</p> <p>Strength and power, introduce progressively more anaerobic training, endurance, complex agility and balance</p>	<p>4-5 dry land sessions per recovery week</p> <p>Strength, power and explosivity (particularly eccentric work), aerobic, efficiency and recovery, anaerobic training, core strength and reactivity to forces of skiing</p>

BOYS

Foundation

Pre &
Post Puberty

Full
Maturation

Phase 1

Phase 2

Phase 3

Phase 4

Phase 5

Phase 6

Endurance

Coordination

Coordination

Coordination

Flexibility

Flexibility

Speed

Speed

Speed

Speed Strength

Static Strength

Power Legs & Arms

Explosive Power

Max Strength

GIRLS

Foundation

Pre &
Post Puberty

Full
Maturation

Phase 1

Phase 2

Phase 3

Phase 4

Phase 5

Phase 6

Endurance

Coordination

Coordination

Coordination

Flexibility

Flexibility

Speed

Speed

Speed Strength

Static Strength

Speed

Power

Speed Strength

Explosive Power

Max Strength

PHYSICAL CONSIDERATIONS (6 - 7Y)

- Development of nervous system is almost complete
- Rate of physical growth is constant, little difference bwtm girls/boys
- Resting heart rate and heart rate during exercise higher than adults
 - ~100 bpm
- Aerobic metabolism predominates during effort; low anaerobic capacity
- Sweating mechanism of children is not well developed
 - Reduces capacity to dissipate heat
 - Children also cool off rapidly and do not tolerate cold nearly as well

PHYSICAL CONSIDERATIONS (8 – 9Y)

- Coordination and stamina improved, grow rate is slow, allows for greater degree of motor control (nervous system development)
- Reaction time is slow; shows an increased ability to make coordinated and quick movements
- Large muscle masses (legs) show a greater degree of development compared to smaller ones.
- Very little potential for increased muscle mass; strength gains result primarily from increased coordination and neural factors.
- RHR and HR with exercise are higher than adults; aerobic metabolism dominates and anaerobic capacity is low.

PHYSICAL CONSIDERATIONS (10-11Y)

- Strength and endurance gains are possible as a result of fitness training
 - Gains are also growth related
- Flexibility improves but should also be trained
- Better visual acuity and depth perception allow for better performance
- In girls, the second half of this period marks the beginning of a major growth spurt that lasts about 3-5 years

PHYSICAL CONSIDERATIONS (12-15 Y)

Girls

- Performance often plateaus due to physiological changes:
 - Performance will continue to improve after this slight phase

Boys

- Significant gains in muscle mass typically occurs one year after PHV due to higher levels of testosterone.

- Coordination and ability to perform skills can be affected by disproportional growth.
- Good time to develop aerobic fitness and flexibility
- Strength and speed endurance training can begin toward the end of this period.

PHYSICAL CONSIDERATIONS (16-17Y)

- Major physiological systems and functions are established
- Appropriate time to develop aerobic capacity
- Significant improvements in strength and anaerobic capacity (speed-endurance)
- Training of power and speed can be done
- Increase muscle mass in boys, due to increased production of hormones
- Growth in girls typically ends at 17-18 years, and at 19-20 years in boys

PHYSICAL CONSIDERATIONS (18Y +)

- Young men stop growing about age 20
- Strength, speed, and power are at their peak in the early 20's and maybe maintained through their early 30s
- Endurance reaches its peak toward the late 20s
 - After the age of 30, physical capacities begin to decline progressively
- Nothing should be avoided, all athletic abilities can be trained

STUDENT ACTIVITY

Use the ATS matrix provided on your thumb drive and the windows of trainability to create a daily training plan based on the problem that has been given to your group. Six people per age group (4 groups):

- Plan a proper warm up
- Main training session – what are your goals for that particular day, why?
 - Support your training decisions and exercise selection/order
- Specificity exercises? How does you plan fit your sport? Skill related fitness?
- Proper cool down
- Recovery plan, when will you train next?