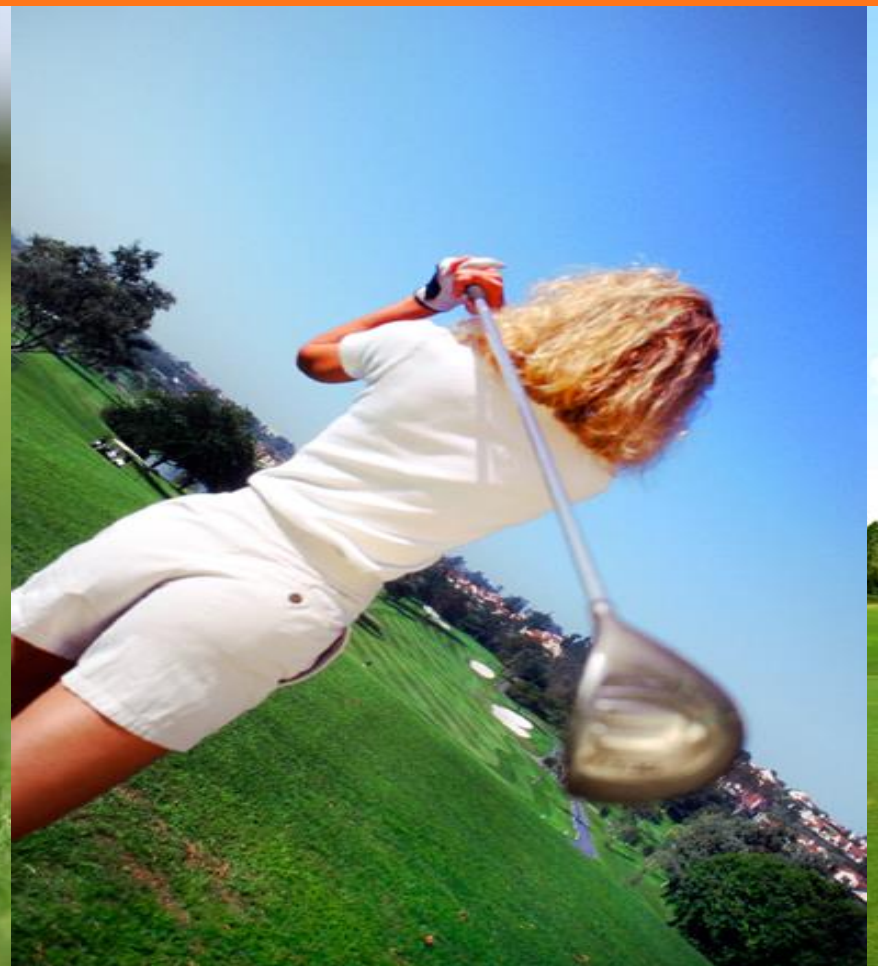
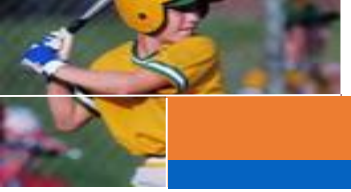
Training for Performance

Dr. Mustafa Qamar

Revive



Training program should match the anaerobic and aerobic demands of the sport



Training Principles

Overload

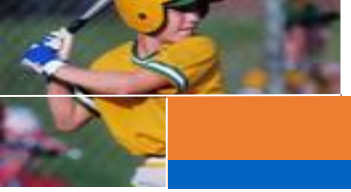
- Increased capacity of a system in response to training above the level to which it is accustomed

Specificity

- Specific muscles involved
- Specific energy systems that are utilized

Reversibility

- When training is stopped, the training effect is quickly lost



Aerobic and Anaerobic Energy Systems in Sports

TABLE 21.1 The Predominant Energy Systems for Selected Sports

Sport/Activity	% ATP CONTRIBUTION BY ENERGY SYSTEM		
	ATP-PC	Glycolysis	Aerobic
Baseball	80	15	5
Basketball	80	10	10
Field hockey	60	20	20
Football	90	10	—
Golf (swing)	100	—	—
Gymnastics	90	10	—
Ice hockey:			
Forwards/defense	80	20	—
Goalie	95	5	—
Rowing	20	30	50
Soccer:			
Goalie/wings/strikers	80	20	—
Halfbacks	60	20	20
Swimming:			
Diving	98	2	—
50 meters	95	5	—
100 meters	80	15	—
200 meters	30	65	5
400 meters	20	40	40
1,500 meters	10	20	70
Tennis	70	20	10
Track and field:			
100/200 meters	98	2	—
Field events	90	10	—
400 meters	40	55	5
800 meters	10	60	30
1,500 meters	5	35	60
5,000 meters	2	28	70
Marathon	—	2	98
Volleyball	90	10	—
Wrestling	45	55	—

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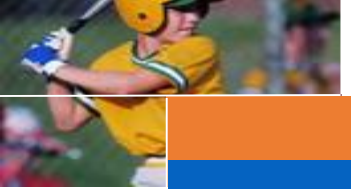
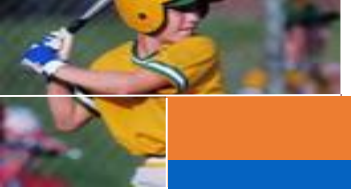


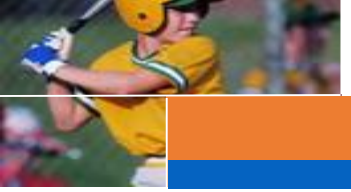
Influence of Gender and Initial Fitness Level

- Men and women respond similarly to training programs
  - Exercise prescriptions should be individualized
- Training improvement is always greater in individuals with lower initial fitness
  - 50% increase in VO_2 max in sedentary adults
  - 10–15% improvement in normal, active subjects
  - 3–5% improvement in trained athletes



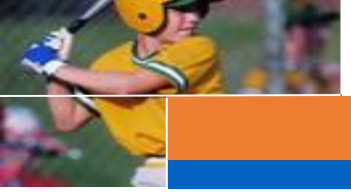
Influence of Genetics

- Genetics plays an important role in how an individual responds to training
  - Åstrand and Rodahl: "If you want to become a world-class athlete, you must choose your parents wisely."
- Anaerobic capacity is more genetically determined than aerobic capacity
  - Training can only improve anaerobic performance to a small degree
  - Dependent largely on fast (IIx) fibers
    - Determined early in development



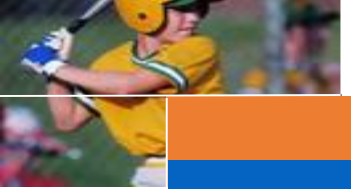
In Summary

- The general objective of sport conditioning is to improve performance by increasing the maximum energy output during a particular movement. A conditioning program should allocate the appropriate amount of training time to match the aerobic and anaerobic demands of the sport.
- Muscles respond to training as a result of progressive overload. When an athlete stops training, there is a rapid decline in fitness due to detraining (reversibility).
- In general, men and women respond to conditioning in a similar fashion. The amount of training improvement is always greater in those individuals who are less conditioned at the onset of the training program.



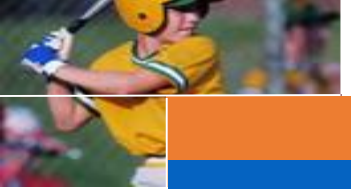
Components of a Training Session

- Warm-up
  - Increases cardiac output and blood flow to skeletal
  - Increases muscle temperature and enzyme activity
  - Opportunity for stretching exercises
    - Believed to reduce risk of muscle injury
- Workout
  - Training session
- Cool-down
  - Return blood “pooled” in muscles to central circulation



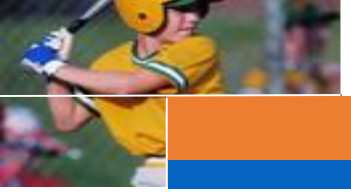
In Summary

- Every training session should consist of a warm-up period, a workout session, and a cool-down period.
- Although limited data exist, it is believed that a warm-up reduces the risk of muscle and/or tendon injury during exercise.



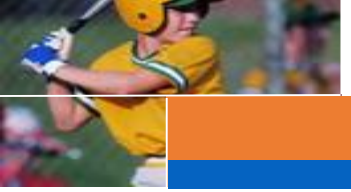
Training to Improve Aerobic Power

- Three methods
  - Interval training
  - Long, slow distance
  - High-intensity, continuous exercise
- Should be geared toward improving:
  - VO_2 max
  - Lactate threshold
  - Running economy



Interval Training

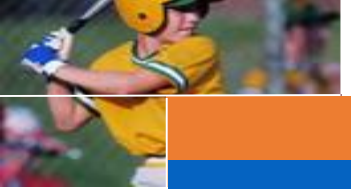
- Repeated exercise bouts
  - Separated by brief recovery periods
- Work interval
  - Distance to be covered
  - Intensity: 85–100% HR_{max}
  - Duration: >60 seconds to improve VO_2 max
- Rest interval
  - Light activity such as walking
  - 1:1 ratio of work to rest
- Number of interval sets and repetitions
  - Depends on purpose of training and fitness level



Determining Intensity for Interval Training

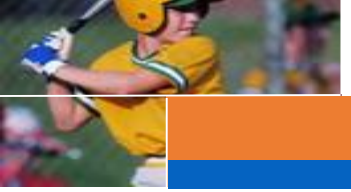
TABLE 21.2 Guidelines for Determining the Intensity or Work Rate During Interval Training for Running and Swimming Different Distances

Interval Training Distances (Yards)		
Running	Swimming	Work Rate for Each Interval
100	25	One to five seconds slower than best time
220	50	Three seconds slower than best time
440	100	One to four seconds faster than average 440-yard run or 100-yard swim times recorded during a mile run or 440-yard swim
880–1,320	165–320	Three to four seconds slower than the average 440-yard run or 100-yard swim times recorded during a mile run or 440-yard swim



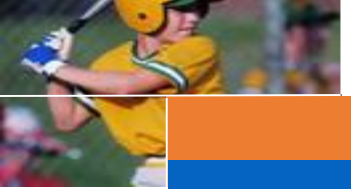
Long, Slow Distance

- Low-intensity exercise
  - 57% VO_2 max or 70% HR_{max}
- Duration greater than would be expected in competition
- Based on the idea that training improvements are based on volume of training
  - However, more is not always better
    - 1.5 hours/day training results in better performance than 3 hours/day



High-Intensity, Continuous Exercise

- Appears to be the best method of increasing VO_2 max and lactate threshold
- High-intensity exercise
  - At or slightly above lactate threshold
  - 80–90% HRmax
    - ≥90% HRmax or 95% HRR also suggested
- Duration of 25–50 min
  - Depending on individual fitness level



Relationship Between Training Intensity and Improvement in VO_2 Max

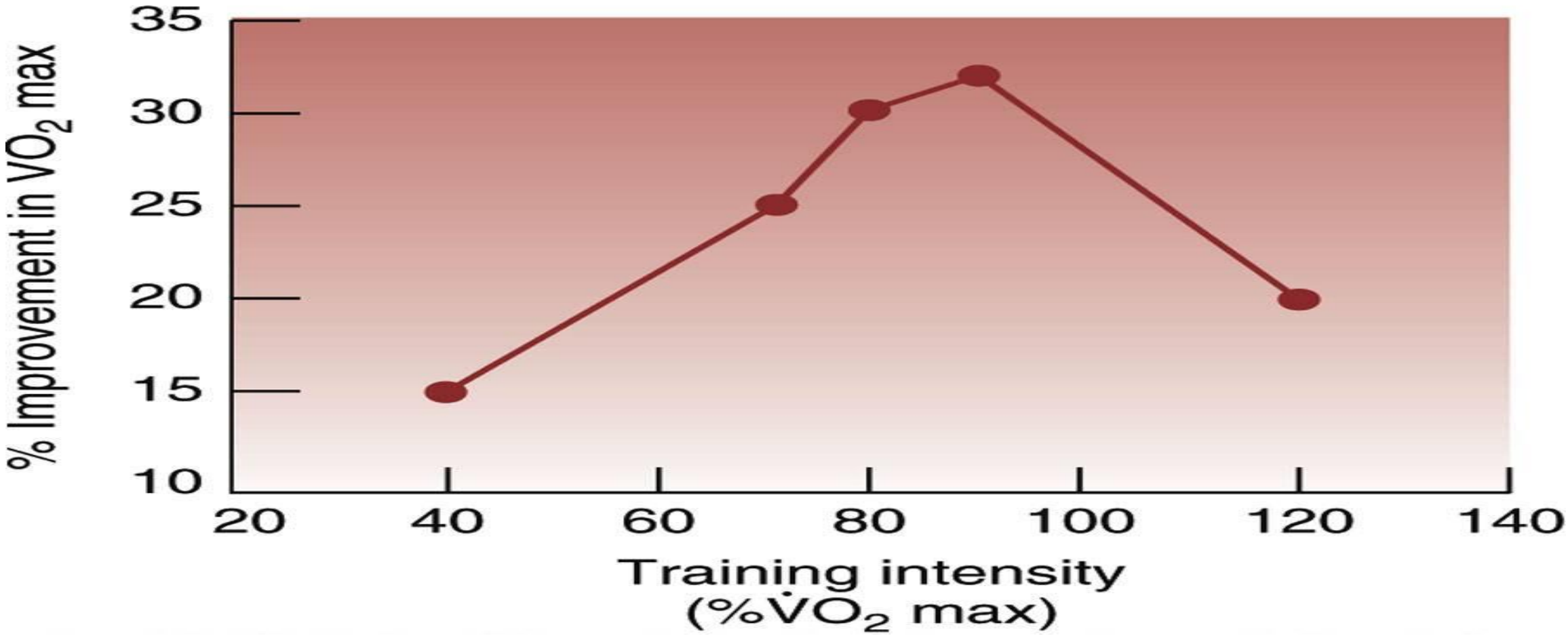
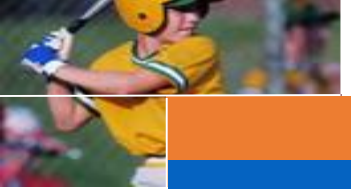
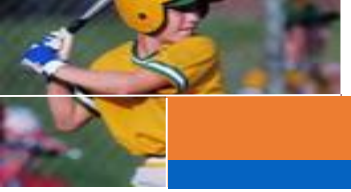


Figure 21.1



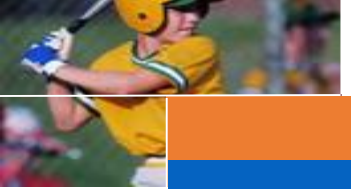
Altitude Training Improves Exercise Performance at Sea Level

- Altitude training may not always improve performance at sea level
  - Lower training intensity at altitude may result in de-training
- Live-High, Train-Low
  - Spend sleeping and resting time at altitude
    - Increases red blood cell volume and oxygen transport capacity of blood
  - Train at lower altitude
  - Better performance gains compared to living and training at sea level



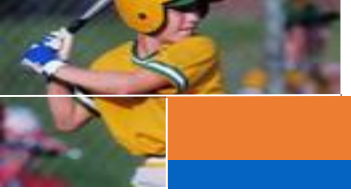
In Summary

- Historically, training to improve maximal aerobic power has used three methods: (1) interval training, (2) long, slow-distance, and (3) high-intensity, continuous exercise.
- Although controversy exists as to which of the training methods results in the greatest improvement in VO_2 max, there is growing evidence that it is intensity and not duration that is the most important factor in improving VO_2 max.
- The “Live-High, Train-Low” altitude training program provides significant endurance performance gains compared to training and living at sea level.



Injuries and Endurance Training

- Most injuries are a result of overtraining
  - Short-term, high-intensity exercise
  - Prolonged, low-intensity exercise
- The “ten percent rule” for increasing training load
  - Increase intensity or duration ≤10% per week
- Other injury risk factors
  - Strength and flexibility imbalance
  - Footwear problems
  - Malalignment
  - Poor running surface
  - Disease (arthritis)

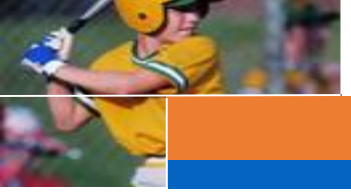


In Summary

- The majority of training injuries are a result of overtraining (e.g., overuse injuries) and can come from either short-term, high-intensity exercise or prolonged, low-intensity exercise.
- A useful rule of thumb for increasing the training load is the “ten percent rule.” The ten percent rule states that training intensity or duration should not be increased more than 10% per week to avoid an overtraining injury.

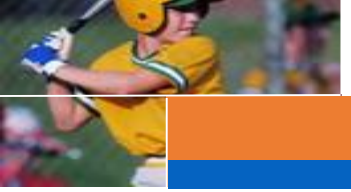
Training to Improve Anaerobic Power

- ATP-PC system
  - Short (5–10 seconds), high-intensity work intervals
    - 30-yard dashes for football players
  - 30- to 60-second rest intervals
    - Little lactic acid is produced, so recovery is rapid
- Glycolytic system
  - Short (20–60 seconds), high-intensity work intervals
  - Very demanding training
    - May alternate hard and light training days



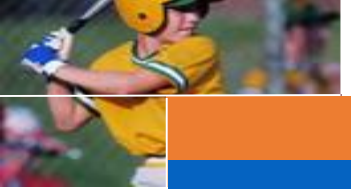
In Summary

- Training to improve anaerobic power involves a special type of interval training. In general, the intervals are of short duration and consist of high-intensity exercise (near-maximal effort).



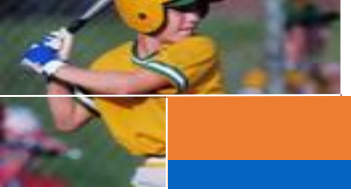
Strength-Training Exercises

- Isometric or static
  - Application of force without joint movement
- Dynamic or isotonic
  - Includes variable resistance exercise
    - Nautilus equipment
- Isokinetic
  - Exertion of force at constant speed



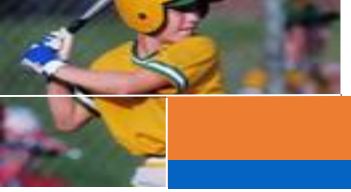
Strength Training Adaptations

- Increased muscle mass
  - Hypertrophy
    - Increased muscle fiber diameter
    - Responsible for most of the increase in muscle size
  - Hyperplasia
    - Increased number of muscle fibers
- Conversion of IIx→IIa fibers
- Central nervous system changes
  - Increased motor unit recruitment
  - Altered motor neuron firing rates
  - Enhanced motor unit synchronization
  - Removal of neural inhibition



Progressive Resistance Exercise

- Improvements in strength via progressive overload
  - Periodically increasing resistance (weight lifted) to continue to overload the muscle
- Basis for most weight-training programs



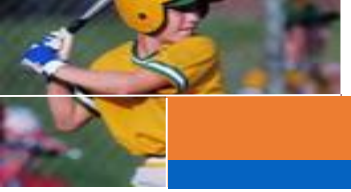
General Strength-Training Principles

- Guidelines:
  - Intensity
    - 4–12 RM
    - Strength gains lower with >15 repetitions

  Number of sets for maximal strength gains
    - Highly trained athletes require 4–8 sets per muscle group
    - 3–8 sets in trained non-athletes
    - 1–4 sets in non-trained individuals
  - Frequency
    - 3 days per week

Should involve muscles used in competition

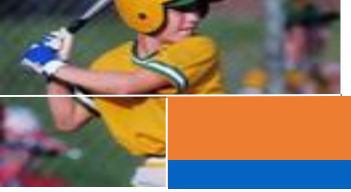
Speed of muscle shortening similar to speeds used in events



Strength Training:

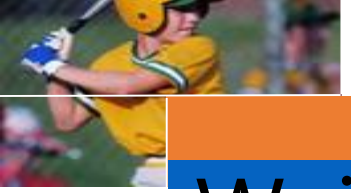
Single Sets Versus Multiple Sets for Maximal Strength Gains

- Some research suggests that one set results in strength gains equal to multiple sets
  - Controversial finding
- Number of sets required differs among subject populations
  - Highly trained athletes
    - 4 to 8 sets
  - Trained non-athletes
    - 3 to 8 sets
  - Un-trained individuals
    - 1 to 4 sets



Free Weights vs. Machines

- Strength gains are similar following training using free weights and machines
- Argument for free weights:
  - Data exist showing that free weights produce greater strength gains
  - Free weights produce greater movement variability and specificity
  - Free weights force control of balance and stabilization
- Disadvantages of free weights
  - Potential for injury
  - Proper lifting technique required
  - Spotters needed

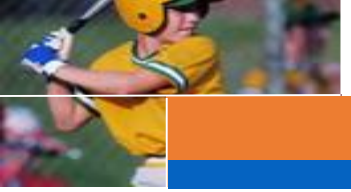


Weight Training Equipment

TABLE 21.3 Summary of Potential Advantages and Disadvantages of Weight-Training Programs Using Various Types of Equipment

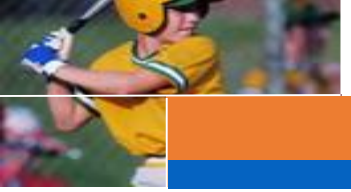
Program	Equipment	Advantages	Disadvantages
Isometric	Variety of home-designed devices	Minimal cost; less time required	Not directly applicable to most sport activities; may become boring; progress is difficult to monitor
Isotonic	Free weights	Low cost; specialized exercises may be designed to simulate a particular sport movement; progress easy to monitor	Injury potential due to dropping weights; increase in workout time due to time required to change weights
Isotonic	Commercial weight machines (i.e., Universal®)	Generally safe; progress easy to monitor; small amount of time required to change weight	Does not permit specialized exercise; high cost
Variable resistance	Commercial devices (e.g., Nautilus®)	Has a cam system that provides a variable resistance that changes to match the joint's ability to produce force over the range of motion; progress easy to monitor; safety	High cost; limited specialized exercises
Isokinetic	Commercial isokinetic devices (e.g., Cybex®)	Allows development of maximal resistance over full range of motion; exercises can be performed at a variety of speeds	High cost; limited specialized exercises

Modified from reference 8.



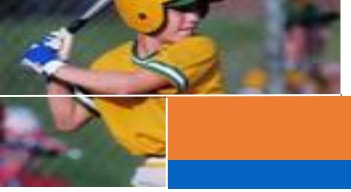
Combined Strength and Endurance Training Program

- Combined strength and endurance training may result in lower gains in strength than strength training alone
  - Depends on:
    - Training state of subject
    - Volume and frequency of training
    - Way the two methods are integrated
- Strength and endurance training should be performed on alternate days for optimal strength gains
  - May be due to fatigue

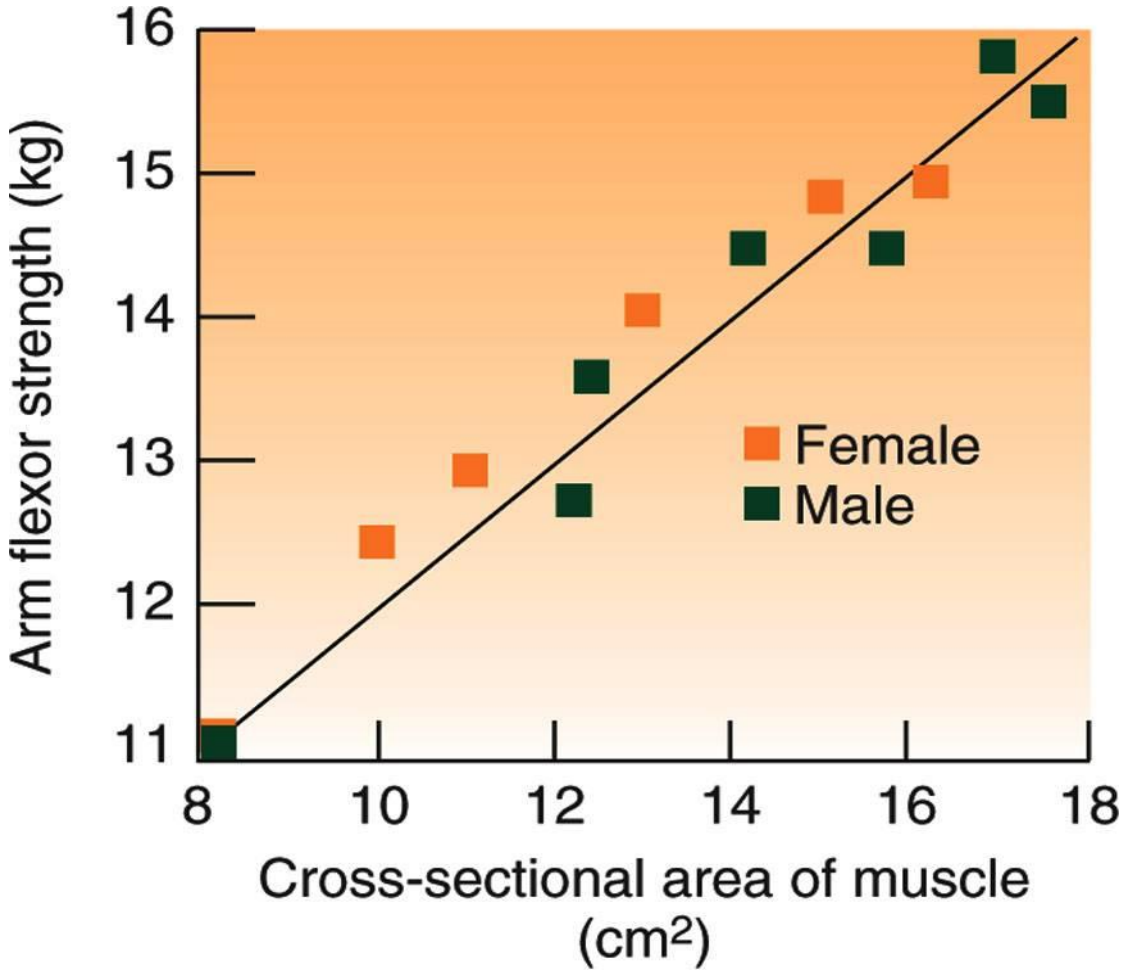


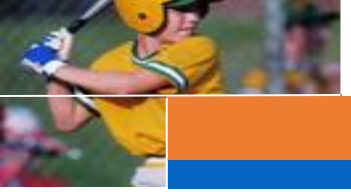
Gender Differences in Response to Strength Training

- Untrained males have greater absolute strength than untrained females
  - 50% stronger in upper body, 30% stronger in lower body
- However, strength related to cross-sectional area of muscle is similar
  - 3–4 kg of force per cm^2 of muscle in males and females
- There does not appear to be a gender differences in response to short-term strength training
  - Men exhibit greater hypertrophy as a result of long-term training
    - Due to higher testosterone levels



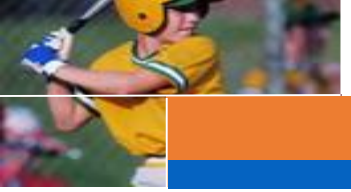
Strength as a Function of Muscle Cross-Sectional Area in Men and Women





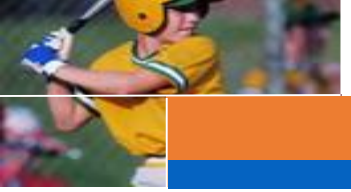
Muscle Soreness

- Delayed onset muscle soreness (DOMS)
  - Appears 24–48 hours after strenuous exercise
  - Due to microscopic tears in muscle fibers or connective tissue
    - Results in cellular degradation and inflammatory response
    - Not due to lactic acid
  - Eccentric exercise causes more damage than concentric exercise
  - Slowly begin a specific exercise over 5–10 training sessions to avoid DOMS



Steps Leading to DOMS

- Strenuous muscle contraction results in muscle damage
- Membrane damage occurs
  - Including sarcoplasmic reticulum
- Calcium leaks out of SR and collects in mitochondria
  - Inhibits ATP production
  - Activates proteases which degrade contractile proteins
- Results in inflammatory process
  - Increase in prostaglandins/histamines
- Edema and histamines stimulate pain receptors



Proposed Model for Delayed Onset Muscle Soreness

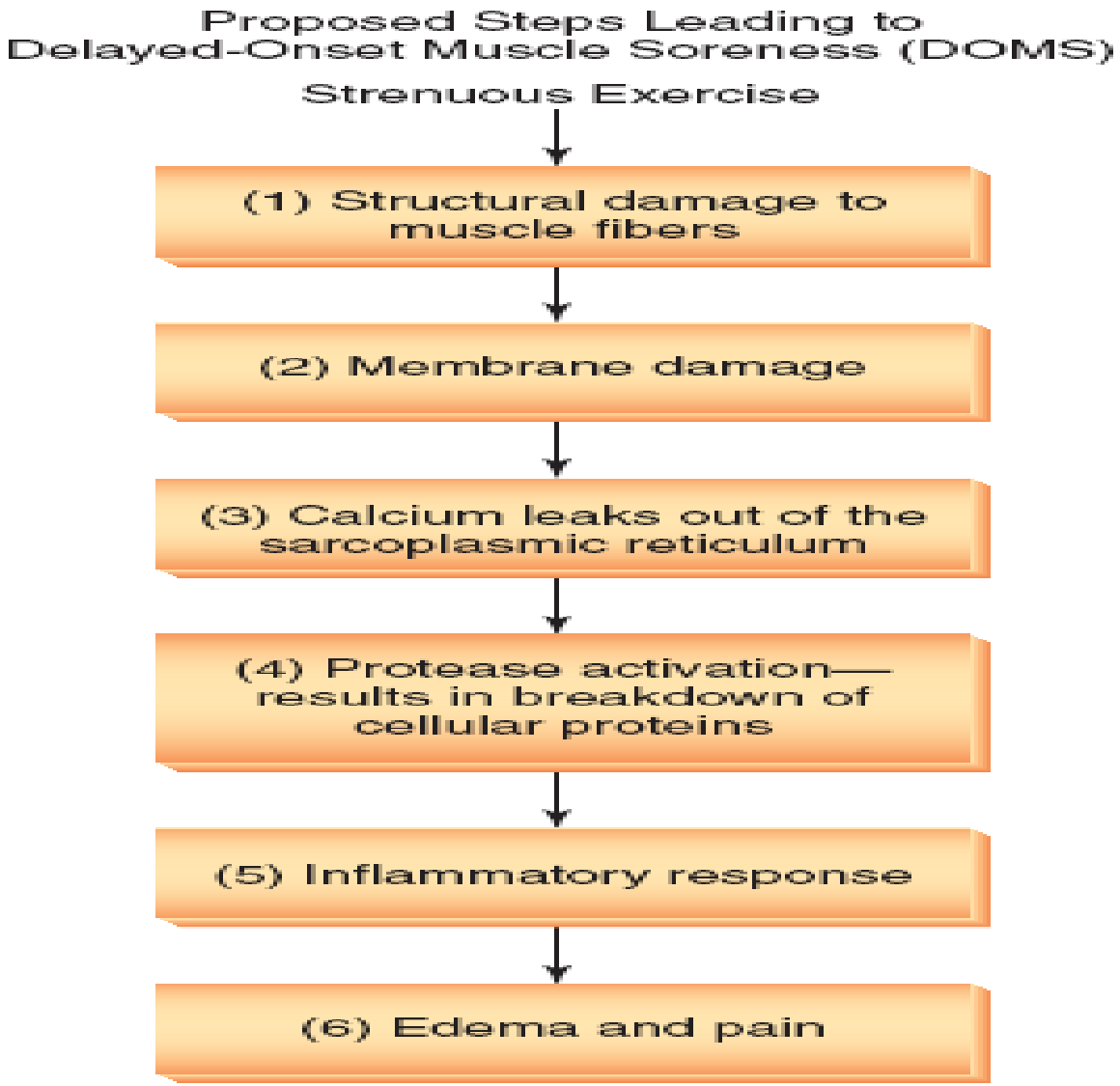
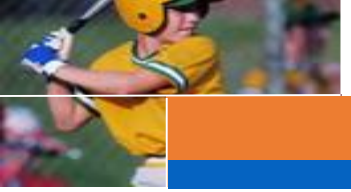
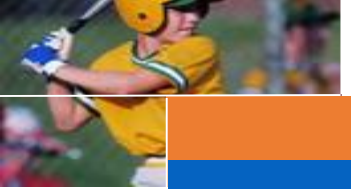


Figure 21.4



The Repeated Bout Effect

- A bout of unfamiliar exercise results in DOMS
  - Following recovery, another bout of same exercise results in minimal injury
- Theories for the repeated bout effect
  - Neural theory
    - Recruitment of larger number of muscle fibers
  - Connective tissue theory
    - Increased connective tissue to protect muscle
  - Cellular theory
    - Synthesis of protective proteins within muscle fiber



Proposed Theories to Explain the "Repeated Bout Effect"

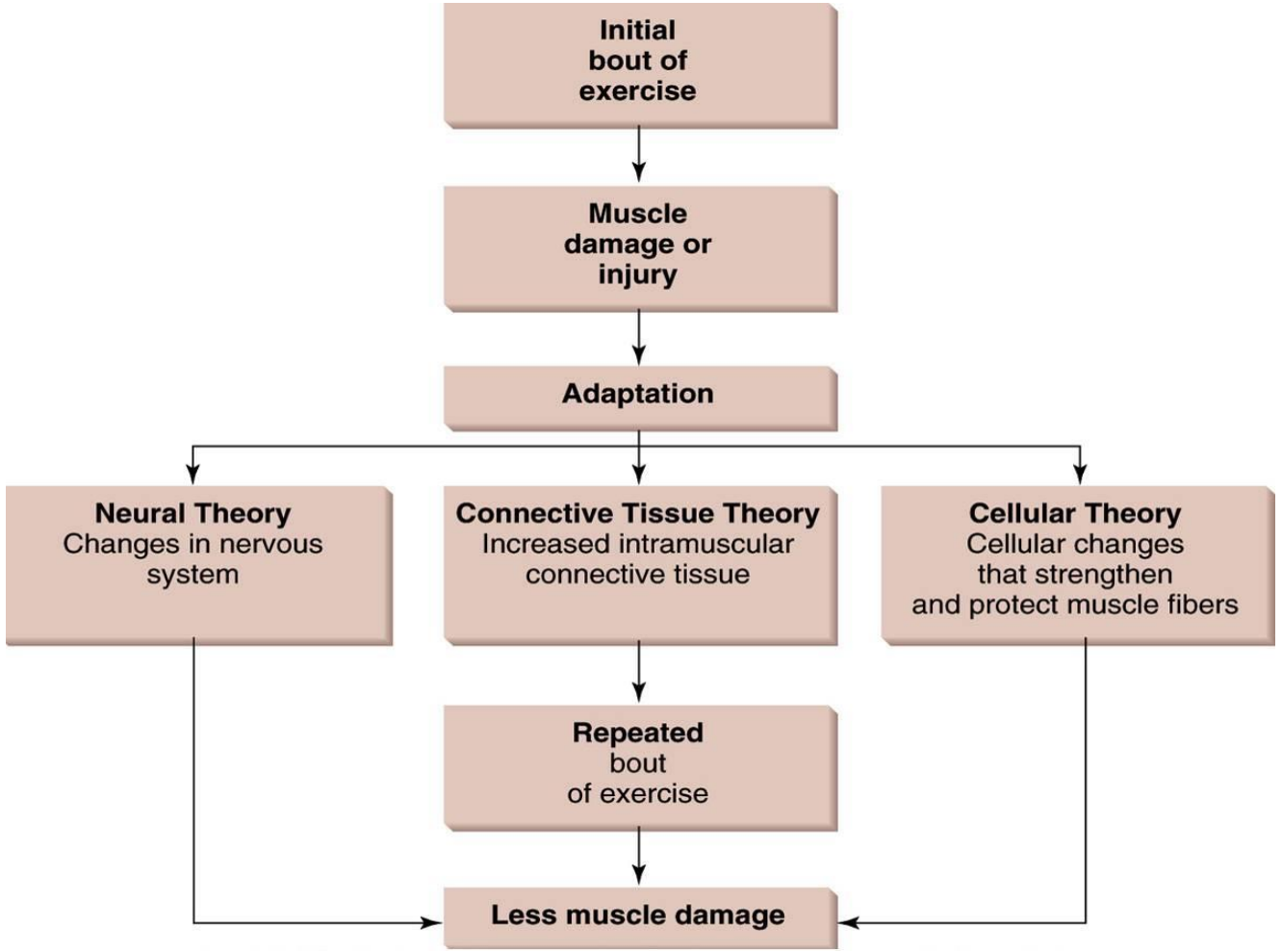
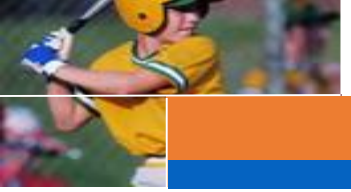
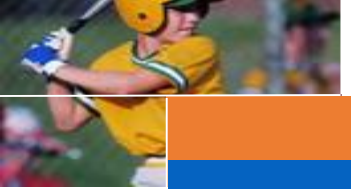


Figure 21.4



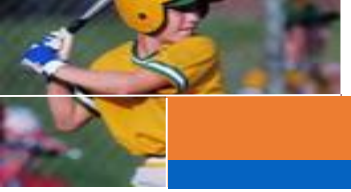
In Summary

- Improvement of muscular strength can be achieved via progressive overload by using either isometric, isotonic, or isokinetic exercise. Isotonic or isokinetic training seems preferable to isometric exercise in developing strength gains in athletes, since isometric strength gains occur only at specific joint angles that are held during isometric training.
- Although untrained men exhibit greater absolute strength than untrained females, there do not appear to be gender differences in strength gains during a short-term weight-training program.



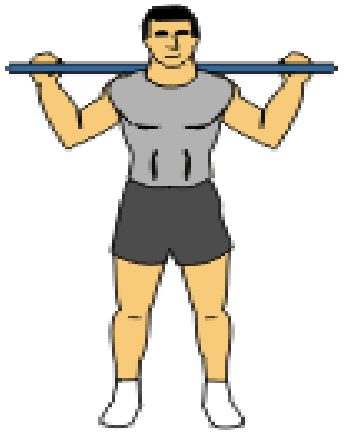
In Summary

- Delayed-onset muscle soreness (DOMS) is thought to occur due to microscopic tears in muscle fibers or connective tissue. This results in cellular degradation and an inflammatory response, which results in pain within twenty-four to forty-eight hours after strenuous exercise.



Training to Improve Flexibility

- Stretching exercises to improve flexibility and efficiency of movement
  - Limited evidence that flexibility reduces injury risk
- Static stretching
  - Continuously holding a stretch position
    - Hold position for 10–60 seconds
    - Repeat each stretch 3–5 times
  - Preferred technique
    - Less chance of injury or soreness
    - Less muscle spindle activity
- Dynamic stretching
  - Ballistic stretching movements
  - **stretching** that involves rapid and bouncing **movements** in a repetitive way and aims at moving the engaged muscles and joints beyond their normal range of motion so as to gradually improve the performing person's flexibility.



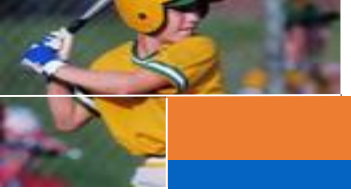
Training to Improve Flexibility

- Proprioceptive neuromuscular facilitation (PNF)
  - Preceding a static stretch with isometric contraction of muscle being stretched
    - Contraction stimulates Golgi tendon organ
  - Requires a training partner

The athlete and partner assume the position for the stretch, and then the partner extends the body limb until the muscle is stretched and tension is felt.

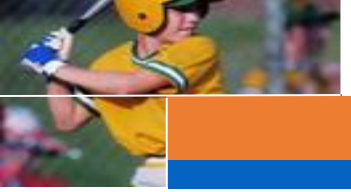
The athlete then contracts the stretched muscle for 5 – 6 seconds

The muscle group is relaxed, then immediately and cautiously pushed past its normal range of movement for about 20 to 30 seconds. Allow 30 seconds recovery before repeating the procedure 2 – 4 times.



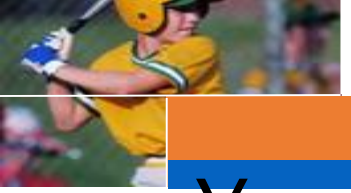
In Summary

- Limited evidence exists to support the notion that improved joint mobility (flexibility) reduces the incidence of exercise-induced injury.
- Stretching exercises are often recommended to improve flexibility and optimize the efficiency of movement.
- Improvement in flexibility can be achieved via static or dynamic stretching, with static stretching being the preferred technique.



Year-Round Conditioning for Athletes

- Off-season conditioning
  - Prevent excessive weight (fat) gain
  - Maintain muscular strength or endurance
  - Maintain bone and ligament integrity
  - Maintain skill level
- Preseason conditioning
  - 8–12 weeks prior to competition
  - Increase to maximum the energy systems used in particular sports
- In-season conditioning
  - Maintenance of fitness level
  - May incorporate periodized techniques

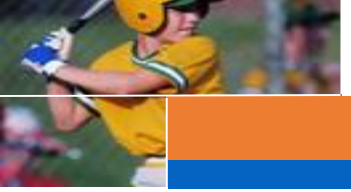


Year-Round Conditioning for Athletes

Suggested Activities for the Various Phases of A Year-Round Training Program

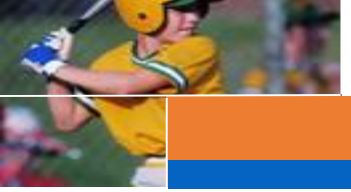
Off-Season	Preseason	In-Season
Weight training	Weight training	Maintenance program
Running	Running	
Skill practice →	Skill practice →	
Participation in other sports	Learning strategies (increased intensity)	

Figure 21.6



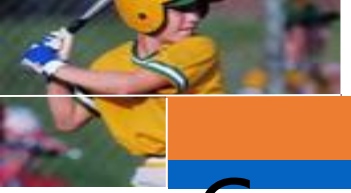
In Summary

- Year-round conditioning programs for athletes include an off-season program, a preseason program, and an in-season program.
- The general objectives of an off-season conditioning program are to prevent excessive fat weight gain, maintain muscular strength and endurance, maintain bone and ligament strength, and preserve a reasonable skill level in the athlete's specific sport.



Common Training Mistakes

- Overtraining
  - Workouts that are too long or too strenuous
  - Greater problem than undertraining
- Undertraining
- Performing non-specific exercises
  - Do not enhance energy capacities used in competition
- Failure to schedule a long-term training plan
  - Misuse of training time
- Failure to taper before a performance
  - Inadequate rest; compromises performance



Common Symptoms of Overtraining

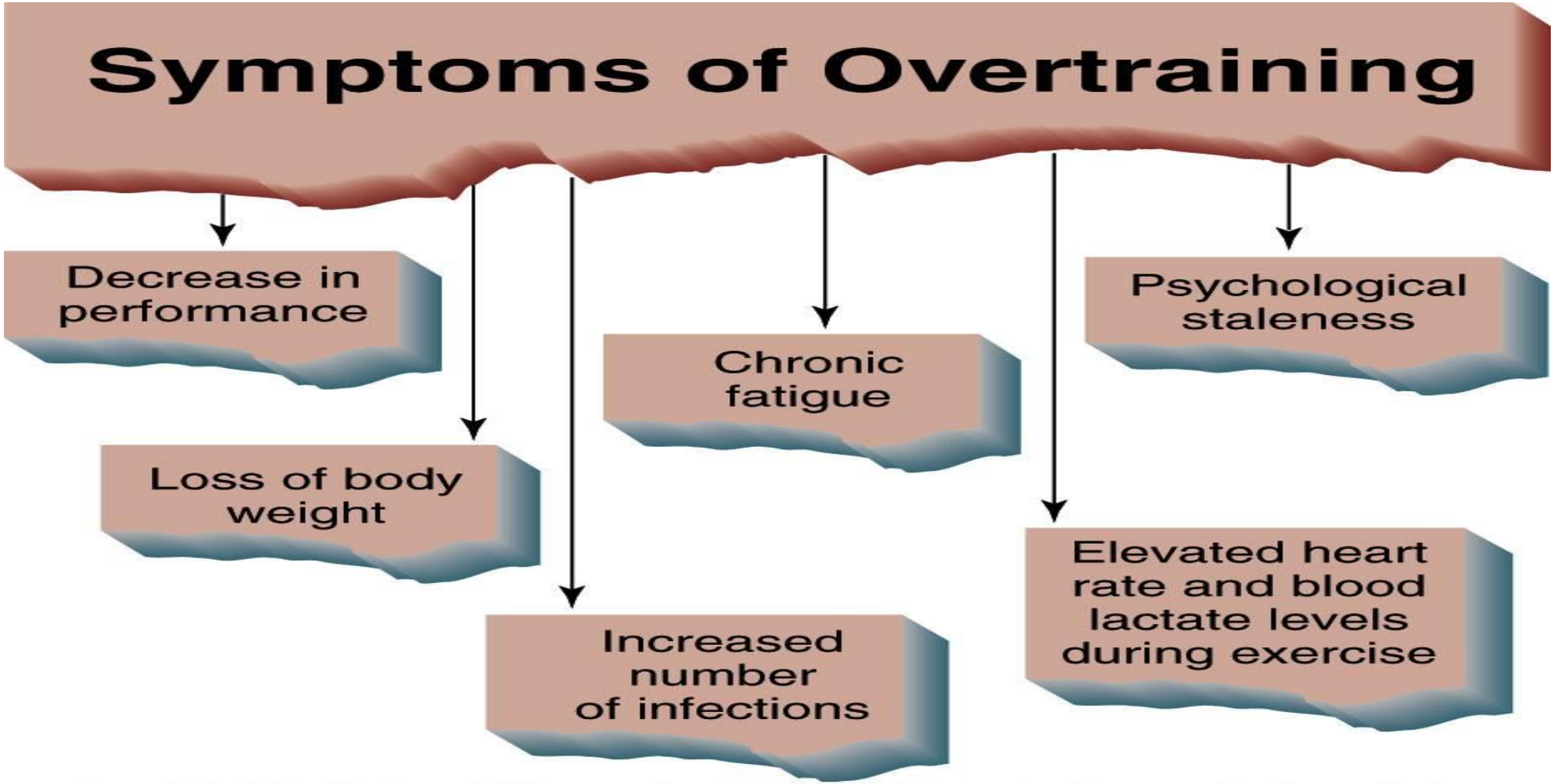
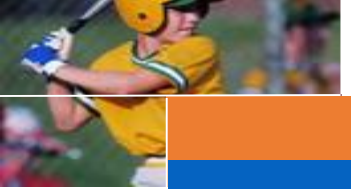
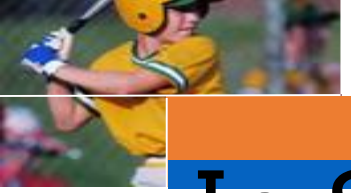


Figure 21.7



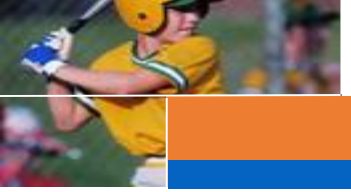
Tapering

- Short-term reduction in training load prior to competition
- Allows muscles to resynthesize glycogen and heal from training-induced damage
- Improves performance in both strength and endurance events
  - Athletes can reduce training load by 60% without a reduction in performance



In Summary

- *Tapering* is the term applied to short-term reduction in training load prior to competition. Research has shown that tapering prior to a competition is useful in improving performance in both strength and endurance events.



In Summary

- Common mistakes in training include undertraining, overtraining, performing nonspecific exercises during training sessions, failure to carefully schedule a long-term training plan, and failure to taper prior to a competition.
- Symptoms or overtraining include: (1) elevated heart rate and blood lactate levels at a fixed submaximal work rate, (2) Loss in body weight due to reduction in appetite, (3) chronic fatigue, (4) psychological staleness (5) increased number of infections, and/or (6) a decrease in performance.