Late phase rehabilitation for pediatric lower extremity injuries and clinical decision making for return to sport.

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Objectives
1. Understand general concepts and specific variables of strength training programs and the risks/benefits of strength training in the pediatric/adolescent population
2. Identify evidence based principles to design and implement an appropriate therapeutic exercise program
3. List the basic principles of strength and conditioning programs as they apply to the pediatric athlete
4. Discuss the current literature regarding lower extremity functional testing
5. Understand how functional testing fits into clinical decision making for return to sport
6. Identify and implement specific functional tests to assist with clinical decision making
7. Implement proper testing procedures to improve safety, reliability, sensitivity and specificity of testing procedures

Strength Training in the Pediatric and Adolescent Population

Why Should We Be Concerned
Statistics: http://www.stopsportsinjuries.org
• Nearly 30 million children and adolescents participate in youth sports
• High school athletes account for an estimated 2 million injuries and 500,000 doctor visits and 30,000 hospitalizations each year
• More than 3.5 million kids under age 14 receive medical treatment for sports injuries each year
• According to the CDC, more than half of all sports injuries in children are preventable

Misconceptions
• Strength training will stunt growth
• Children and adolescents do not have enough hormones to build strength
• Strength training will harm growth plates
• Strength training decreases flexibility
• Machines are safer and more effective than free weights

Chronological vs Biological Age
• Chronologic age is defined by years and/or months
  – Girls 8-13, boys 9-15
• Biologic age is defined in stages of maturation or pubertal development
  – Skeletal age, somatic (physique) maturity, sexual maturation
  – Girls sexual maturity is marked by menarche
  – Boys sexual maturity by pubic hair, facial hair, deepening voice
Chronological vs Biological Age

• It is important to recognize maturation to evaluate growth and development patterns
  – Sensitivity to individual differences in abilities and experiences is very important when developing a rehabilitation program

• Peak height velocity
  – During a growth spurt there is an increased risk of injury
  – 12 in females and 14 in males
  – Weakened bone, muscle imbalances, and tightening of the tendons increase the risk of overuse injuries “Growing Pains”

Tanner Staging

<table>
<thead>
<tr>
<th>Stage</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No pubic hair, no breast development, bone age &lt;11</td>
<td>No pubic hair, bone age &lt; 14</td>
</tr>
<tr>
<td>2</td>
<td>Minimal pubic hair, breast buds (11.2)</td>
<td>Normal pubic hair (11.6)</td>
</tr>
<tr>
<td>3</td>
<td>Enlargement of breasts, axillary hair (12.0)</td>
<td>Voice changes, penis enlargement (12.3)</td>
</tr>
<tr>
<td>4</td>
<td>Axillary enlargement, adult pubic hair (12.4)</td>
<td>Axillary hair (13.6)</td>
</tr>
<tr>
<td>5</td>
<td>Mature female (14.0)</td>
<td>Mature male (14.4)</td>
</tr>
</tbody>
</table>

• Progression through stages takes 2-4 years
• Variability in age of onset is to be expected however progression is predictable

The Musculoskeletal System

• More collagen and cartilage than ossified adult bones
• Increased vascularity and thicker periosteum than adult bones
• Bone Growth is faster than soft tissue growth

The Neuromuscular System

• Change in length tension ratio affects proprioception and coordination
• Athletes must learn their body before they can learn a new activity, exercise or lifting technique

Therapeutic Implications

• Same mechanism – different injuries
• Physis is prone to injury
• Muscle insertion prone to injury (apophysitis or avulsion)
• Rapid bone growth leads to tight tissues, and changes in coordination
When is it Safe to Begin Strength Training

- Most young athletes have these characteristics and can maintain proper balance and postural control around 7 or 8 years of age
- A desire to participate
- The discipline to train
- The ability to listen and follow directions

Physiologic Changes Secondary to Strength Training

- Muscle hypertrophy (size)
- Muscle hyperplasia (number)
- Muscular endurance (type I and Ila)
- Increased ligament and tendon strength
- Muscle fiber angle changes (lines of stress)
- Increased bone density

Physiological Changes Secondary to Strength Training

- Increased Metabolic Energy Stores
  - Increased ATP (energy)
  - Increased creatine phosphate (building block)
  - Increased glycogen (fuel)
  - Increased mitochondria
- Neuromuscular enhancement - synchronicity and recruitment

Changes Specific to (Heavy Load) Strength Training

- Neuroendocrine adaptation
  - Increase in anabolic hormones
    - Testosterone
    - IGF
    - HGH
- Cellular adaptation
  - Increased permeability
  - Increased receptor membrane sensitivity to anabolic factors

Strength Training Principles
Exercise Programming-Design Variables

- Needs analysis
- Exercise selection
- Frequency
- Order
- Load
- Reps
- Volume
- Rest

Exercise Programming- Exercise Selection

- Exercise Selection:
  - Core - multi-joint with large muscle recruitment
  - Assistance - single joint
  - Structural - load the spine
  - Power - structural exercise performed quickly
- SAID - Specific adaptation to imposed demands
  - Sport and activity specific training

Exercise Programming- Progression

- Motor Control Progression
  - Closed chain
  - Single joint to multiple joint
  - Simple to complex
  - Slow to fast
  - Light to heavy

Exercise Programming- Training Age

<table>
<thead>
<tr>
<th>Training Status</th>
<th>Current Program</th>
<th>Training Age</th>
<th>Frequency (Per Week)</th>
<th>Training Intensity</th>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginner</td>
<td>Now-on, Just starting</td>
<td>&lt; 2 months</td>
<td>1-2</td>
<td>Low</td>
<td>None / Minimal</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Currently Training</td>
<td>2-6 months</td>
<td>2-3</td>
<td>Medium</td>
<td>Basic</td>
</tr>
<tr>
<td>Advanced</td>
<td>Currently Training</td>
<td>1+ years</td>
<td>3-4+</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

Exercise Programming-Training Age

- **Beginner** - less than 6 months of weight training experience
  - Cannot squat, deadlift or bench press bodyweight, has no linear stability
- **Intermediate** - 6 - 18 months of weight training experience
  - Bodyweight squat, deadlift and bench press, has linear stability and adequate rotary stability
- **Advanced** - 12+ months of weight training experience
  - 1.5x bodyweight squat, deadlift and bench press.

Exercise Programming- Frequency

<table>
<thead>
<tr>
<th>Sport Season</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off-Season</td>
<td>4-6</td>
</tr>
<tr>
<td>Preseason</td>
<td>3-4</td>
</tr>
<tr>
<td>In-Season</td>
<td>1-3</td>
</tr>
<tr>
<td>Postseason (active rest)</td>
<td>0-3</td>
</tr>
</tbody>
</table>
Exercise Programming - Order

- Exercise Order: 4 common strategies
  - Power-Cor-Assistance
  - Upper body Lower body (Alternated)
  - “Push” and “Pull”
  - Supersets and Compound Sets

Exercise Programming

<table>
<thead>
<tr>
<th>Training Goal</th>
<th>Load (%1RM)</th>
<th>Reps</th>
<th>Sets</th>
<th>Rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength</td>
<td>&gt;85</td>
<td>6</td>
<td>2-6</td>
<td>2-5 minutes</td>
</tr>
<tr>
<td>Power: Single Effort</td>
<td>80-90</td>
<td>1-2</td>
<td>3-5</td>
<td>2-5 minutes</td>
</tr>
<tr>
<td>Power: Multiple Effort</td>
<td>75-85</td>
<td>3-5</td>
<td>3-5</td>
<td>2-5 minutes</td>
</tr>
<tr>
<td>Hypertrophy</td>
<td>67-85</td>
<td>6-12</td>
<td>3-6</td>
<td>30-60 seconds</td>
</tr>
<tr>
<td>Endurance</td>
<td>&lt;67</td>
<td>&gt;12</td>
<td>2-3</td>
<td>30 seconds</td>
</tr>
</tbody>
</table>

Exercise Programming - Plyometric Volumes

- Points of contact
- Speed
- Height
- Body weight

<table>
<thead>
<tr>
<th>Experience</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginner</td>
<td>90-100</td>
</tr>
<tr>
<td>Intermediate</td>
<td>100-200</td>
</tr>
<tr>
<td>Advanced</td>
<td>120-240</td>
</tr>
</tbody>
</table>

Strength Training Principles

S.A.I.D. Principle (Good or Bad?)

- Specific
- Adaptation to
- Imposed
- Demand

Calculating 1RM
Calculating 1 RM

- Perform a light warm up 5-10 reps
- Estimate a load that can be complete 3-5 reps
- Increase weight 5-10% for upper body or 10-20% for lower body
- 2-4 minute rest and repeat
- If the athlete failed decrease the weight by 5% for upper body and 10% for lower body
- Is calculating 1RM important for the pediatric/adolescent population?

Exercise Progression

Regional Interdependence

- Refers to the concept that seemingly unrelated impairments in a remote anatomical region may contribute to or be associated with the patient's primary complaint
- Assess movement and changes in respiration
- Don’t think of each individual component of a system in isolation

Movement Progressions

- Sagittal plane → Frontal plane → Transverse plane
- Re-educate shifting and rotation
- Integrate alternating and reciprocating movements
- Stability- alignment with integrity under load

“Don’t place fitness on top of dysfunction”
Gray Cook
"Coach for an improved pattern rather than a predetermined pattern or a one-size-fits-all approach. There’s no best way to squat if you refer to specifics such as joint angles, or feet position, etc., but I do believe there are ‘ideal’ strategies to teach."

Dr. Mark McKeans

Squat Progression

- Air Squat → Front Squat → Back Squat → Overhead Squat
- Performance Points:
  - Neutral spine
  - Weight on heels
  - Depth below parallel
  - Knee over second toe

Deadlift Series

- Deadlift
- Performance Points:
  - Lumbar curve
  - Weight on heels
  - Shoulders forward of bar
  - Hips and shoulders same rate
  - Shrug before pull
  - Ball caught in squat below parallel

Squat vs. Deadlift

Lunge Progression

- Planes
- Surface
- Perturbation
- UE movement
- EO/EC
- Walking
- Step Through
Romanian Deadlift Progression
- Planes
- Surface
- Perturbation
- UE movement
- EO/EC

Single Leg Anterior Progression
- Surface
- UE movement
- EO/EC
- Accuracy
- Rotation
- Elevation
- Outside Stimulus

Lateral Jump Progression
- Surface
- UE movement
- EO/EC
- Accuracy
- Rotation
- Elevation
- Outside Stimulus

Single Leg Lateral Progression
- Surface
- UE movement
- EO/EC
- Accuracy
- Rotation
- Elevation
- Outside Stimulus

Squat Jump Progression
- Surface
- EO/EC
- Accuracy
- Elevation
- Outside Stimulus

Lunge Jump Progression
- Surface
- EO/EC
- Accuracy
- Elevation
- Outside Stimulus
Training into Valgus?

Activity Specific Training

Functional Testing for Return to Sport

Why Use Functional Testing

- Assessment of the patients current functional status
- Objective and quantitative
- Mimics functional and sport movements
- Assists with patient, parent, and clinician coordination and communication
- Motivate patients by showing their progress over time
- Assist clinicians with intervention and goal selection
- Decrease injury risk upon return to sport or activity

Objective vs. Subjective Testing

- Objective or Performance based outcome measures include those tests that are physically completed by the patient
- Subjective or self report measurements are questionnaires or surveys completed by the patient/family in regards to current level or functional capacity
- The difference between these 2 types of measures reveals a distinction between patient/client perceived or self-measured ability to perform a task or activity and the clinically or professionally measured performance of a task or activity
Subjective Assessments

- Tampa Scale of Kinesiophobia
- Anterior Cruciate Ligament – Return to Sport after Injury Scale
- IKDC
- LEFS
- KOS/KOS Sport
- (KODS)
- Cincinnati Knee Scoring Scale
- Lysholm
- Tegner
- Athletic Fear Avoidance Questionnaire

Who Gets a Functional Test

- ACL reconstruction
- Knee scope
- Hip scope
- Ankle sprain
- Everyone?

When to Test

- <1 joint effusion
- Full pain free ROM
- Normal gait
- >80% quad strength index
- Pain free hopping
- >12 weeks postoperative (ACL)

When to Test

- Demonstrate proper form with:
  - Squat
  - Single leg squat
  - Lateral step down
  - Perturbation training
  - Broad/Vertical jump
  - Single hop
- Psychological concerns?

RTS Testing Battery

- Hop test
- Lateral hop test
- LESS
- Tuck Jump assessment

Hop Testing

Hop Testing

- Perform tests in the order they appear, begin with non-operated limb.
- One practice trial is given. No restrictions on arm movement.
- Two alternating trials on both limbs are measured and means for each are recorded.
- Start with lead toe behind marked line.
- A failed jump consists of loss of balance, touching the floor with arms or opposite leg, or an additional short hop on landing.

Calculating Limb Symmetry Index:
- Average the two recorded trials on each limb.
- Divide the operative limb average by the non-operative limb average, and multiply by 100.
- Once "Limb Symmetry Index" values are calculated for each of the 4 hop tests, the average of these is taken for the "Overall Combination" score.
- Overall Goal for Return to Sport is >90%.

Single Leg Lateral Hop

- Tests endurance of involved lower extremity
- Procedure: Place 2 lines 12 inches apart. The patient will balance on one leg and hop laterally over the opposite line, landing on the same leg. The patient must maintain their balance and return to the start position, this is repeated for 30 seconds.
- Bad hops include a loss of balance or touching the line
- Goal= 90%

Landing Error Scoring System

- Begin standing on a 30 cm high box
- Landing area ½ participants body height away from box
- Participants are instructed to jump just past the line and jump as high as possible
- <4 excellent
- >6 poor

Tuck Jump Assessment

- Perform continuous tuck jumps for 10 seconds
- Lifting knees to hip height and landing on the same spot
- Scored in 3 areas knee & thigh:
  - Knee and thigh motion
  - Foot position with landing
  - Plyometric technique
- Low score indicates better performance (6)
Tuck Jump Assessment

<table>
<thead>
<tr>
<th>Item</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee &amp; thigh motion</td>
<td>0</td>
</tr>
<tr>
<td>Knee valgus on landing</td>
<td>0</td>
</tr>
<tr>
<td>Thighs not reaching parallel (peak)</td>
<td>0</td>
</tr>
<tr>
<td>Thighs not equal side to side (flight)</td>
<td>0</td>
</tr>
<tr>
<td>Foot position during landing</td>
<td>0</td>
</tr>
<tr>
<td>Foot placement not shoulder width apart</td>
<td>0</td>
</tr>
<tr>
<td>Foot placement not parallel (front to back)</td>
<td>0</td>
</tr>
<tr>
<td>Foot contact timing not equal</td>
<td>0</td>
</tr>
<tr>
<td>Does not land in same foot print</td>
<td>0</td>
</tr>
<tr>
<td>Excessive landing contact noise</td>
<td>0</td>
</tr>
<tr>
<td>Plyometric technique</td>
<td>0</td>
</tr>
<tr>
<td>Flats between jumps</td>
<td>0</td>
</tr>
<tr>
<td>Technique declines prior to 10 seconds</td>
<td>0</td>
</tr>
<tr>
<td>Total Score</td>
<td>0</td>
</tr>
</tbody>
</table>

Other Testing Procedures

- Square Hop Test
- Vail Sport Test
- Shark Skill
- LEFT test
- Sport Cord Test
- T-Test
- Pro Agility
- Illinois Agility
- Three Cone Shuttle
- 4 Corners
- Hexagon

Gradual RTS

- Allow a gradual transition-drills in practice
  - Unopposed practice
  - Opposed practice
  - Scrimmage
  - Game situations

Optimal RTS Testing

Knee Re-injuries Following ACL Reconstruction

Re-injuries in those who Failed and those who Passed RTS Criteria
Improving Functional Testing

- Ensure the athlete can demonstrate symmetry on basic tests before advancing to higher level testing.
- Consider the demands of the sport and level of the athlete when choosing tests. Not all of the higher level tests may be appropriate - look at your risk to benefit ratio.
- Use a test battery or group of tests to maximize sensitivity and ensure that deficient athletes are not cleared for sport.
- Standardize warm-up and testing procedures, including hand placement to minimize compensation.

Take Home Functional Testing

- There is no consensus on timeframe for return to sports.
- Do not rely solely on one test or a calendar.
- Consider subjective and objective findings.
- Assess quality of movement.
- NO EVIDENCE BASED GUIDELINES FOR RTS

Take Home Strength Programming

- 6 to 8 exercises that train the major muscle groups.
- Balanced program.
- 1 to 2 sets with 6 to 15 reps.
- Initial load 10 to 15 repetitions with but no muscle failure.
- Increase load 5% to 10% when the child can perform 15 reps.
- Rest 1 to 3 minutes between sets.
- Train 2 to 3 nonconsecutive days each week.

Questions

References

References


