Neuromuscular Training: The First Line of Defense

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DISCLOSURE

I have no relevant disclosures related to this topic.

Objectives

Identify populations at risk for knee ligament injury.

Define Neuromuscular Training.

Understand motor control and its role in neuromuscular training.

Discuss knee ligamentous injury preventative strategies.

Injury Overview

Non-contact injuries
- cut/pivot type

Direct Contact injuries
- force directed at the knee itself

Indirect contact
- force directed at the system resulting in knee injury

Who is at Risk?

Sport types
- Level 1 sports ie. basketball, soccer, football
- Level 2 sports ie. skiing, baseball, volleyball

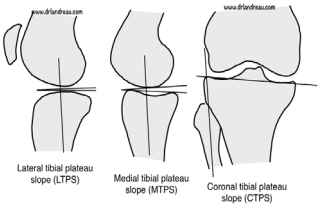
Previous injury
- 11.3 times more likely to tear during the first year and 4.4 times more likely in the second year after surgery
  - Graft or contralateral

Who is at Risk?

Anatomic Factors
- Tibial plateau factors – depth and slope
- Intercondylar notch – Narrow notch may lead to increased risk
- Joint laxity – knee, ankle, generalized
- High BMI

High volume athletes
- athlete exposure varies by sport

Tibial plateau slopes



Who is at Risk?

Neuromuscular factors

- Dynamic Valgus
- Trunk Displacement
- Muscle imbalance (Hamstring to Quad)
- Reduced 'triple flexion'
- Stiff legged landing/greater ground reaction forces/shorter stance time

What is Neuromuscular Training (NMT)?

Training enhancing unconscious motor responses by stimulating both afferent signals and central mechanisms responsible for dynamic joint control.

In other words…

- Any training technique that helps the nervous system generate improved muscle firing patterns.
  - Increase dynamic joint stability
  - Decrease joint forces
  - Re/learn movement patterns and skills
- More generally, any training techniques that facilitates improved movement coordination.
- Can it be strength related? Agility related? Power related? Plyometric related?

NMT

The goal being to improve motor control and develop automatic motor programs consistent with healthy body position during movement.

- Typical for us to target the trunk, core, hips, knees and ankle collectively and individually.

Recent data showed 50% reduction in all ACL injuries, with 67% reduction in in non-contact injuries in females.

Motor Control

The process of initiating, directing, and grading purposeful voluntary movement.

- It is the nervous systems contribution to movement
- Responsible for speed, magnitude, direction, posture and position

Neuromuscular training can the process in which motor control is optimized.

- Providing task/context oriented training
- Repetition with appropriate cues

Effective NMT Programs

- Preseason and in season components
- 2-3 times per week frequency
- Yearly performance to encourage retention
- Supervision from skilled/trained personnel
- Addition as part of warm up or existing S & C programming

Effective NMT Programs

- Education of athletes, parents, coaches
  - Padua et al. lists specific educational components
- Age appropriate sessions and intervention
- Targeted intervention for at risk athletes specifically level ½ sport participants and those who have previously sustained ACL injuries.

But NMT also improves performance…

Macro Level
- Start Faster
- Stop Faster
- Jump Farther
- Increased COD ability
- Increased kick velocity
- Increased ball accuracy
- Improved reaction time

Micro Level
- Increase muscle recruitment
- Increased proximal to distal coordination
- Improved COM distribution

What is my Role?

Keys for NMT
- Identify suboptimal/risk related movement processes
- Educate athlete on corrections
- Intrinsic/extrinsic cues
- Establish environment where athlete can successfully make corrections
- Find mastery at lower level
- Challenge/load movement to adapt to situational needs

What is my Role?

Case 1

- 7 mos. s/p ACLR, soccer athlete
- midpoint jump training comes to you from another clinic
- Lands like this >>>
- Intrinsic Cue
  - "Land with your knees in alignment with your hips feet"
- Extrinsic Cue
  - w/ band around knees, "press into the band"

What is my Role?

Case 2

- 4 1/2 mos s/p ACLR volleyball player
- Beginning jump training as part of post-operative rehab
- Lands like this >>>
- Intrinsic cue
  - "Land with increased knee flexion"
- Extrinsic cue
  - "Land like a ninja"

Functional Therapy/Prevention

Rehab/prevention focused on returning a patient to a certain task.

- Movement context
- Load context

***More than just whether the foot on the ground or not!*

What are the best options for NMT?

Sportsmetrics – Cincinnati Sports Medicine

- 3 times per week for 6 weeks focused on dynamic warm up, jump/plyometric training, strength training and flexibility.
- Sessions are 60 minutes separate from practices.

PEP (Prevent Injury and Enhance Performance) – Santa Monica Sports Medicine

- 3x/week program focused on warm-up, stretching, strengthening, plyometrics and sport specific movements.
- Should take 15-20 minutes to perform prior to practice

What are the best options for NMT?

FIFA 11+

- Dynamic warm up system
- Implemented in 15-20 minutes prior to practice/games

What else is out there?

Many strength and conditioning companies offer their own injury reduction methods.

Create your own methods as part of rehab using available resources/research.

- Example: Using LESS as scoring criteria for landing mechanics.

Landing Error Scoring System Item	Operational Definition of Error	Scoring
Knee flexion: initial contact	The knee is flexed less than 30° at initial contact.	0 = Absent 1 = Present
Hip flexion: initial contact	The thigh is in line with the trunk at initial contact.	0 = Absent 1 = Present
Trunk flexion: initial contact	The trunk is vertical or extended on the hips at initial contact.	0 = Absent 1 = Present
Ankle plantar flexion: initial contact	The foot lands heel to toe or with a flat foot at initial contact.	0 = Absent 1 = Present
Medial knee position: initial contact	The center of the patella is medial to the midfoot at initial contact.	0 = Absent 1 = Present
Lateral trunk flexion: initial contact	The midline of the trunk is flexed to the left or the right side of the body at initial contact.	0 = Absent 1 = Present
Stance width: wide	The feet are positioned greater than shoulder width apart (acromion processes) at initial contact.	0 = Absent 1 = Present
Stance width: narrow	The feet are positioned less than shoulder width apart (acromion processes) at initial contact.	0 = Absent 1 = Present
Foot position: external rotation	The foot is externally rotated more than 30° between initial contact and maximum knee flexion.	0 = Absent 1 = Present
Foot position: internal rotation	The foot is internally rotated more than 30° between initial contact and maximum knee flexion.	0 = Absent 1 = Present
Symmetric initial foot contact: initial contact	One foot lands before the other foot or 1 foot lands heel to toe and the other foot lands toe to heel.	0 = Absent 1 = Present
Knee-flexion displacement	The knee flexes less than 45° between initial contact and maximum knee flexion.	0 = Absent 1 = Present
Hip-flexion displacement	The thigh does not flex more on the trunk between initial contact and maximum knee flexion.	0 = Absent 1 = Present
Trunk-flexion displacement	The trunk does not flex more between initial contact and maximum knee flexion.	0 = Absent 1 = Present
Medial-knee displacement	At the point of maximum medial knee position, the center of the patella is medial to the midfoot.	0 = Absent 1 = Present
Joint displacement	Stiff: the participant demonstrates a large amount of trunk, hip, and knee displacement. Average: the participant has some, but not a large amount of, trunk, hip, and knee displacement. Stiff: the participant goes through very little, if any, trunk, hip, and knee displacement.	0 = Stiff 1 = Average 2 = Stiff
Overall impression	Excellent: the participant displays a soft landing with no frontal-plane or transverse-plane motion. Average: all other landings. Poor: the participant displays large frontal-plane or transverse-plane motion, or the participant displays a stiff landing with some frontal-plane or transverse-plane motion.	0 = Excellent 1 = Average 2 = Poor

Bottom Line

ACL injury frequency in sports can be reduced with use of targeted neuromuscular intervention.

These specific programs can and should be implemented by healthcare practitioners such as Athletic Trainers, Physical Therapists and Strength/Conditioning staff to maximize healthy participation.

References

- Becker, J., & Wu, W. F. (2015). Integrating biomechanical and motor control principles in elite high jumpers: A transdisciplinary approach to enhancing sport performance. *Journal of Sport and Health Science, 4*(4), 341-346. doi:10.1016/j.jshs.2015.09.004
- **Benjaminse et al. (2015) Optimization of the Anterior Cruciate Ligament Injury Prevention Paradigm: Novel Feedback Techniques to Enhance Motor Learning and Reduce Injury Risk. Journal of Orthopedic and Sports Physical Therapy. 45 (3): 170-182**
- Brach, J. S., et al. (2015). Improving Motor Control in Walking: A Randomized Clinical Trial in Older Adults With Subclinical Walking Difficulty. *Archives of Physical Medicine and Rehabilitation, 96*(3), 388-394. doi:10.1016/j.apmr.2014.10.018
- **Sugimoto et al. (2015) ABCs of Evidence-based Anterior Cruciate Ligament Injury Prevention Strategies in Female Athletes. Current Physical Medicine and Rehabilitation Reports. 3(1): 43-49.**
- **Padua et al. (2018) National Athletic Trainers' Association Position Statement: Prevention of Anterior Cruciate Ligament Injury. Journal of Athletic Training. 53 (1): 5-19**
- Padua, D. A., et al.(2015). The Landing Error Scoring System as a Screening Tool for an Anterior Cruciate Ligament Injury–Prevention Program in Elite-Youth Soccer Athletes. *Journal of Athletic Training, 50*(6), 589-595. doi:10.4085/1062-6050-50.1.10
- Smith et al. (2012) Risk Factors for Anterior Cruciate Ligament Injury: A Review of the Literature — Part 1: Neuromuscular and Anatomic Risk. Sports Health. 4(1), 69-78
- Smith et al. (2012) Risk Factors for Anterior Cruciate Ligament Injury: A Review of the Literature—Part 2: Hormonal, Genetic, Cognitive Function, Previous Injury, and Extrinsic Risk Factors. Sports Health. 4(2), 155-161.