Dancing with the Surgeon
A Brief Look at the Biomechanics of Dance and Injury Prevention

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Goals

• Background
• Prevalence of injury
• Benefits of the arts
• Biomechanics as related to dance (including supportive medical literature)
• Injury specifics relative to body region
• Injury prevention
• Question/Answer
Disclaimer

• This is not meant to be an all-encompassing lecture on all possible dance injuries, but rather the more common injuries encountered.

• The intention is not to induce fear to excel in dance, but rather to promote a safe and successful dance career by increasing injury awareness and prevention techniques.
Show of Hands

- How many of you have had an injury as a result of dance?
Show of Hands

• Keep your hand up if you received treatment for this injury
Show of Hands

• How many of you are still having issues related to that injury?
Dance Injuries

- Lifetime injury incidence of 90% for professional dancers
  - 60-70% are related to an overuse injury

- Reported rates for ballet and modern dance suggest 0.62 to 18.3 injuries per 1000 hours of exposure to dance
  - Tap dance demonstrates lower injury rates of 0.31 injuries per 1000 hours of exposure
Dance Injuries

• Lower extremity injuries are the most common with up to 48% related to the foot and ankle
  – Exception to this is with hip hop, particularly with breakers, where upper extremity injuries become more common
Benefits of Dance

- Obvious cardiovascular health benefits associated with being active
- Improved flexibility, strength, and endurance
Benefits of Dance

• Body fat in female dancers averages 43% lower than that of non-dancers
  – This is understandable considering the aesthetic constraints of dance
  – However, it is of the utmost importance to ensure an appropriate lean body mass and muscular strength
Benefits of Dance

- Improves postural control in comparison to non-dancers
- Repetitive training aids in shifting from a visual to a proprioceptive dominant strategy for posture regulation
Benefits of Dance

• Stress relief and overall sense of well-being
• Study demonstrating that participation in a 6 week course of aerobic dance resulted in enhanced self-perception and a significant reduction in body image dissatisfaction
• Goal setting
The Dancing Athlete
The Dancing Athlete

- Unique blend of artist and athlete
- Attempting to create seemingly effortless maneuvers at the extremes of motion
The Dancing Athlete

• Dancers often have unique constraints in regards to timing of performances, casting opportunities, and aesthetic requirements
Dance versus Football
Dance versus Football

• Dancers may experience different injuries but frequency is no less
• Contrary to other sports, dancers have
  – No “off season”
  – No on-field substitutions
  – Not generally considered a “team” sport
Question#1

Volunteer?
Question#1

• What is the lifetime incidence for injury for a professional dancer?

A. 10%
B. 40%
C. 70%
D. 90%
E. None of the above
Question#2

Volunteer?
Question#2

Which of the following are benefits of dance?

A. Improved flexibility
B. Cardiovascular health
C. Worsened balance
D. All of the above
E. Both A and B
F. None of the above
Injury
Injury

• Majority of injuries are related to cumulative microtrauma, as opposed to one single incident
  – The cumulative nature is most often related to chronic positioning faults in combination with muscular imbalance and strength deficits
Injury Factors

Intrinsic Factors
• Age
• Male versus female
• Hyper mobility or hypo mobility
• Personality type
• Prior injury history

Extrinsic Factors
• Muscular strength
• Cardiovascular fitness
• Personal style and unique attributes
• Lighting, stage obstructions, flooring
• Costume/shoe wear
• Overtraining
• Fatigue
Respect Your Mind

- The mind is a powerful tool that can help to keep your body in check.
- Pain results as feedback from the body to command our attention and allow us to react appropriately to diminish the pain.
Warning signs

• Progressively worsening pain (during rehearsals, class, training, etc)
• Pain present during particular actions (jumps, arabesque, lifts, etc)
• Pain becoming more and more pronounced with less and less activity
• Loss of function
Ideal Management of Injury

• Much like a see-saw
• Return of function should be maximized while time away from dance should be minimized without introducing significant risk of reinjury
Team Approach

- Factors involved in the maintenance of a healthy dancer include teachers, artistic directors, choreographers, employers, parents, friends, colleagues, healthcare providers
Team Approach

- Crucial for the healthcare provider (MD, PT, ATC, etc) to work closely with dance instructors, directors, choreographers, and others to allow for efficient and effective return to dance
Team Approach

• Important for the provider to have specific understanding of the unique demands and nuances of movements involved with dancing
Team Approach

• Parents play a crucial role in injury prevention
  – Important to be mindful of the advancement to different levels of training to ensure the dancer is adequately prepared
  – Important to be mindful of nutrition and emotional factors (idealistic attitude)
Team Approach

• Females tend to start dancing on average at age 6-8, males at age 10-12
  – Early recognition of technical faults and injuries along the way can improve the ability to continue dancing
There is no “I” in Team

• Not entirely true
• The dancer is the best advocate for their own health by regulating their own behaviors through
  – Rest
  – Proper diet/hydration
  – Adjunct training
  – Shoe and costume fit
  – Social support
  – Seeking clinical help when needed
Question#3

Volunteer?
Question#3

• True or False?- The majority of injuries sustained in dance are as a result of cumulative microtrauma (as opposed to one single event)

True
Question#4

Volunteer?
Question#4

• All of the following are extrinsic risk factors for injury except
  A. Prior injury history
  B. Shoe wear and costume
  C. Fatigue
  D. Muscular strength
  E. Cardiovascular strength
Question#5

Volunteer?
Question#5

• Which of the following are warning signs for injury?

A. Pain becoming progressively worse with less and less activity
B. Loss of function
C. Pain present during particular movements or activities
D. Progressively worsening pain
E. All of the above
Hurdles
Hurdles

• Important for those involved with the injured dancer to recognize that injury can precipitate feelings of depression and a decreased sense of self worth.
Hurdles

- Dancers (as do other athletes) tend to strive for perfectionism and daily bests
- Sense of responsibility to team and for performances
- Often feel they are being judged by peers or fearful of losing performance opportunities
Don’t Cry Over Spilled Milk
Desired Outcome

• By applying sports science to dance training/performance, one can strengthen and extend the career of a dancer
• The aim is for a “fit for purpose” body which can aid performance, reduce risk of injury, and ensure a long career
Why Me?
Why Me?

• Not all dancers are created equal
  – Even when matched for background, years of training, and body type, dancers use differing strategies to keep balance during routines and perform certain maneuvers

• Elite dancers demonstrate different and superior motor strategies than less experienced or novice dancers
Injury Prone? No

- Dancers in general demonstrate excellent balance and proprioception compared to other sports (ability to know what your body is doing without looking)
- Dancers have improved automated postural control in comparison to non-dancers
Injury Prone?

Yes

• Traditional classical ballet training, rehearsals, and performances do not yield enough stimuli to increase the aerobic fitness level to the desired amount
  – However, a high aerobic fitness level is required for most routines
• Dancers have excellent range of motion and strength in the hips but weak upper body, torso, hamstrings, and quadriceps in general
Fatigue
Fatigue

• How many of you have experienced or know a colleague who has experienced an injury in the last few rehearsals leading up to a show?
Fatigue

• Significantly increases risk for injury
  – 90 percent of professional dancers who had injuries reported feeling tired just before the injury
  – 80 percent of these were injured during high-intensity workouts
  – 79 percent had danced at least 5 consecutive hours prior to injury
Fatigue

• Protective mechanisms become less reliable
• Fatigue can be related to multiple factors
  – Sleep deprivation
  – Poor nutritional intake or hydration
  – Overexertion
  – Stress
Strength
Strength

- Studio work alone does not provide enough strength training to develop the needed muscular strength
- Important consideration when cross-training
- Dancers with decreased thigh muscular power have an increased incidence of lower extremity and lower back injuries
Strength?

• Historically strength training in dance has not been emphasized partly due to a fear that increased muscular size would render unpleasing aesthetics.
Supplemental Strengthening

• Supplemental strength training for hamstring and quadriceps muscles has been shown to help protect professional ballerinas from fatigue related to their dance routines
  – Increased benefit noted in those dancers who are weaker to begin with
Supplemental Strengthening

• Aesthetics are not significantly compromised
Question#6

Volunteer?
Question#6

- True or False?- Through application of sports science, we can help to create a “fit for purpose” body that can help to reduce the risk for injury and achieve a long-lasting career

True
Question#7

Volunteer?
Question#7

• All of the following are contributors to fatigue except
  A. Staying up until 1am updating Facebook page the night before a performance
  B. Skipping lunch to go to rehearsal
  C. Stressing about a big test the week of the show
  D. Getting to bed early for a good night’s rest before you hit the studio the following day
  E. Pushing the limits during rehearsal until your legs become wobbly
Turnout

• One of the most fundamental parts of the framework of classical ballet

• Ideally turnout should be achieved though external rotation at the hips primarily
Turnout

• Ability to perform turnout related to
  – Soft tissue pliability
  – Muscular strength
  – Anatomic constraints
Turnout

• Compensatory strategies
  – Using floor friction as a supplement
  – Screwing the knees
  – Over pronation of the feet (rolling the feet flat)
  – Anterior pelvic tilt which causes lumbar lordosis (arching)
Turnout

• Unfortunately these strategies may help turnout but significantly increase the risk for overuse injury

• Greater risk of injury noted in dancers where compensated turnout is greater than the actual hip external rotation turnout
Can I Improve My Turnout?

- Age at which turnout training is initiated is one of the most important factors in the development of turnout.
- In terms of bone development, the most responsive period is noted between ages 11 and 14.
  - Training at least 6 hours per week allows increased retro-torsion of the femurs to allow for increased external rotation and improved turnout.
Can I Improve My Turnout?

• Dancers in general have increased external rotation of the hips compared to the non-dancer population
  – This goes to show that training allows significant improvement for turnout, thereby decreasing the need to use compensatory mechanisms

• Similar dynamic seen in baseball pitchers with external rotation at the shoulder
Jumps
Jumps

• Landing from jumps leads to significant peak ground reactive forces
  – If knee and ankle joints are less flexible, this can precipitate injury more readily
Jumps

- Due to aesthetic requirements, landings typically occur on a single outstretched leg resulting in significant forces through the lower extremity.
Jumps

• Commonly instructed to land with lower extremity in near full extension with a vertical spine and maximal plantar flexion of the ankle to allow the dancer to “roll through” the foot and dissipate landing forces

• Males and females tend to use a hip-dominant strategy to protect the lower extremity on landings
Jumps

• As a result of increased training and experience with particular jumps, dancers have improved consistency with landing mechanics and avoid injury prone landings
  – Dancers beginning training during youth demonstrate improved hip control following landing
Jumps

• Important not to attempt jumps that you have not been properly trained for
Impact

• Tap dance tends to have low ground reaction forces in comparison to leaps in other forms of dance
  – However, less skillful dancers often demonstrate higher ground reaction forces and are prone to more injuries
Impact

- Irish rock step yields ground reaction forces of 4.5 times body weight
  - Contact force at ankle joint is 14 times body weight
  - Repetition with this significantly elevated force can lead to injury, especially if the mechanics are not correct
Question#8

Volunteer?
Question#8

- Compensatory strategies for increasing turnout include
  A. Overpronation of the feet
  B. Using the floor as friction
  C. Tilting the pelvis forward
  D. Going to the orthopaedic surgeon to have surgery so that your legs will rotate further
  E. All of the above
  F. A, B, and C
Question#9

Volunteer?
Question#9

• True or False?- Turnout should primarily be achieved through the hips

True
Question#10

Volunteer?
Question #10

• Landing from jumps ________ the ground reaction force

increases
Pointe Readiness
Pointe Readiness

• Chronological age has been used as one of the most popular criteria
  – 96% of dance institutions use this as the primary prerequisite for going en pointe
  – 39% of instructors use age 12 for a cutoff
  – Problematic in that musculoskeletal maturity and motor development are highly variable
Pointe Readiness

- Majority agree that regardless of age, a minimum of 3-4 years of training prior to beginning pointe work is necessary
  - However, duration and intensity of training is not necessarily standardized
- Ankle plantar flexion has also been used to help determine aptitude for going en pointe
Pointe Readiness - Pitfalls

- There is a decrease in motor ability and dynamic balance during adolescence from the sensorimotor adjustment to rapid growth change
  - This may make going en pointe dangerous at this stage
Pointe Readiness- Pitfalls

• Professional ballerinas average 113 degrees of plantar flexion
• If adequate flexion is not present, the foot and ankle will compensate with a neutral foot alignment and expose the lateral ankle ligaments to increased stress
Pointe Readiness- Pitfalls

• Several studies demonstrate increased posterior ankle pain and injury rates in dancers beginning pointe prior to demonstrating sufficient pre-existing plantar flexion
Pointe Readiness - Pitfalls

- Weak hip abductors lead to increased postural sway and subsequently inversion forces on the ankle during single leg stance
  - Therefore adequate hip abductor strength is crucial to being able to attain pointe position
Question#11

Volunteer?
Question #11

- Risk factors that make going en pointe dangerous include
  - A. Decreased plantar flexion of the ankle
  - B. Weak hip abductors
  - C. Inadequate balance
  - D. All of the above
  - E. A and B
  - F. B only
Question#12

Volunteer?
Question#12

- True or False? - The majority agree that a minimum of 2 weeks of dance training are needed to begin pointe training

False
Hip Injuries
Hip Injuries

• Hip flexor tendonitis
  – Inflammation of the flexors of the hip as they cross the joint in the front, often secondary to tightness of the tendons
  – Often exacerbated by activities involving extreme hip movements
  – Typically responds well to medications, rest, therapy, +/- injections
  – Infrequently requires surgical release
Hip Injuries

- **Iliotibial band syndrome**
  - Inflammation of the outer portion of the hip, often secondary to tightness of the iliotibial band
  - Typically responds well to rest, medications, therapy, +/- injections
  - Infrequently requires surgical release
Knee - Patella

- Patellar subluxation as a result of abnormal foot alignment and twisting
- Often related to muscular imbalance between the inside and outside of the knee
- Typically treated conservatively with bracing, therapy, and rest
Knee - Meniscus

• Meniscal tears may occur as a result of twisting and overloading the knee
• Small tears can be treated conservatively
• Often require surgery
Medial Tibial Stress Syndrome

• aka “Shin Splints”
• Pain over the posteromedial aspect of the mid to lower tibia due to the pull of the calf muscles on the bone attachments
• Commonly treated with medications, rest, therapy
Tibial Stress Fracture
Ankle

- Across all forms of dance, ankle injury rates are as high as 31%
- Occurs as a result of the extreme ankle range of motion and stability that are required for dance
Ankle

• Dance is unique in that maximal plantar flexion is often used (such as en pointe)
  – This places significant stress on the lateral ankle ligaments
Ankle

- Sprains of the lateral (outside) ligaments of the ankle often take 6-12 weeks to fully heal the ligaments
- Proprioceptive and balancing capability significantly decrease following injury
Ankle

• Inappropriately rehabilitated ankle injury can lead to chronic ankle instability
  – This causes a vicious cycle whereby the ankle is unable to protect itself from further injury

• Repetitive bouts of lateral ankle instability and recurrent ankle sprains
  – Pain, swelling, feeling of weakness
Ankle Impingement

• Also can develop scar tissue within the ankle joint which can further cause pain through impingement

• Initially typically treated conservatively with rest, therapy, and injections

• Surgery is sometimes necessary to remove the impinging structures
Achilles Tendonitis

- Often the result of repetitive plantar flexion events at the ankle (e.g. pointe, demipointe)
- Commonly responds to rest, therapy, medications
Achilles Rupture

• Can result from a single acute event (landing from a jump) or from prolonged Achilles tendonitis with partial tearing
Achilles Rupture

• Often require surgical management if complete
Os Trigonom

• Present in 7-11% of the general public
• Can become symptomatic when ankle is placed in extreme positions
Os Trigonom

- Can lead to bony impingement due to compression between the tibia and the calcaneus during extreme plantar flexion (i.e. pointe and demipointe)
Os Trigonum

- The simple presence of an os trigonum does not imply that it will cause issues.
- Symptoms are not necessarily relative to size of os trigonum.
- Impingement can worsen following ankle sprain as foot shifts forward on the ankle joint causing further impingement.
  - Emphasizes importance of ankle rehabilitation.
Os Trigonum

• Initial treatment involves activity modification, anti-inflammatory medications, and therapy

• Sometimes surgical removal is required
  – Surgery is beneficial for pain relief but will not necessarily improve pointe (os trigonum has been present since birth so motion does not acutely improve)
Flexor Hallucis Tendonitis

- Tendonitis of the flexor hallucis longus as it passes around the backside of the ankle joint
- Over time can form a nodule in this region which can cause “triggering” of the great toe
- Often seen in combination with an os trigonum
Flexor Hallucis Tendonitis

- Often responds to rest and anti-inflammatory drugs
- Occasionally requires injections under ultrasound guidance or surgery for removal of scar tissue
Plantar Fasciitis

- Inflammation at the insertion of the plantar fascia onto the calcaneus (heel)
- Frequently responds to stretching and activity modification
Avulsion Fractures

• Fracture of the 5th metatarsal due to plantar flexion-inversion ankle sprains
  
  – This force occurs particularly when landing from a jump into a demipointe position
Avulsion Fractures
Sesamoiditis

- Typically resultant from overuse
- Most bothersome en pointe or demipointe
Sesamoiditis

• Frequently responds to rest, medication, therapy, shoe wear modification
• Infrequently requires surgery for removal of one or both sesamoids or repair if fractured
Back Injury

• 9.4 to 23% of injuries in pre-professional and professional dancers involve the back
Back Injury

- Males are at greater risk secondary to lifting duties
Why are there Back Injuries?

• Positions involving end range extension motions are integral to the aesthetics of dance

• An example is the most basic form of back extension, a cambre
Back Injuries

• Arabesque and attitude involve increased lumbar extension as end range hip extension is met
Back Injuries- Pitfalls

- Technical errors can lead to dangerous increased lumbar extension
- An example of this involves forms requiring increased turnout, for which dancers often compensate with increased anterior pelvic tilt, leading to hyperextension of the spine
Stress Fractures

- Fracture through the pars interarticularis with resultant slippage of one vertebrae on another
I Can Work Through the Pain?

• In persons with pre-existing back pain, there is a change in the pattern of activation of muscles during movements.
I Can Work Through the Pain?

- Typical response to sudden spinal loading involves the recruitment of particular muscles to protect the spine but in patients with pre-existing spinal pain, there is an inappropriate response with firing of large muscle groups which do not allow proper protection for the spine.
Back Injury Prevention

• Proper technique is crucial to prevent inadvertent hyperextension

• Limit daily lifting repetitions to help reduce fatigue and potential for overuse injury to the spine
  – Catch 22 because under training can be even more dangerous
Overall Health

• For youth and adolescents, dance training during development of the body in combination with dietary restriction can lead to bone mineral density reduction and altered development, including problems with the reproductive system
Overall Health

• Nutrition is crucial, as deficiency does not allow the body to respond appropriately for function and healing
• Adequate warm-up and stretching before dance is important for injury prevention
• Cool-down period following dance workout
Question #13

Volunteer?
Question#13

• The first line treatment for the majority of injuries sustained during dance is

A. Surgery
B. Ending your dance career
C. Rest, therapy, medications
D. Becoming a professional go-kart racer
E. Full body cast
Injury Management Keys

- Initial treatment with protection, rest, ice, compression, and elevation during the acute phase
Injury Management Keys

• Timely evaluation and treatment
  – Often on-site at performances, rehearsals, in the studio

• Knowledge of prior injury history is important as this introduces different variables in regards to increased reinjury risk and modified rehabilitation
Injury Management Keys

• Early restoration of motion and stability
• Dance specific rehabilitation
• Supervised return to dance to ensure safety from multiple perspectives
  – Prior to return to unrestricted activity, must be able to demonstrate mastery of rehabilitation techniques and specific dance exercises/movements
Summary of Prevention

• Learn and practice correct technique
• Limit practice duration and frequency (age appropriate) to prevent developing significant fatigue
• Identify troublesome maneuvers and particular weak spots and work with a knowledgeable instructor to improve
Summary of Prevention

• Appropriate shoe wear and dance surfaces
• Hydrate 30 minutes prior to dance and during/after as needed
• Adequate dietary consumption to provide the appropriate nutrients for activity and healing
Summary of Prevention

• Warm-up and stretch before and after dance workouts/performances
  – Emphasize neck, back, hip, knee, and ankle muscles
  – Be wary of overstretches if already hyper flexible

• Ideal warm-up and stretch should take approximately 30 minutes to adequately raise the heart rate and warm the muscles prior to exertion
Summary of Prevention

- Strengthening program and cross-training, emphasizing spine, hip, knee, and ankle
- There is currently a trend for professional ballet dancers across the world to cross-train for conditioning purposes
  - Helps to prevent overuse and strain on particular muscles as a result of fatigue
Summary of Prevention

• Recognize and report injuries as they occur so they may be properly managed to prevent further worsening or more serious injury
Question #14

Volunteer?
• Injury prevention techniques include
  A. Adequate warm-up and stretching
  B. Appropriate dietary intake and hydration
  C. Early identification of injury
  D. Practicing correct technique
  E. Cross-training and strengthening
  F. All of the above
  G. None of the above