Chronic Ankle Instability, mechanical and functional control issues contributing to lateral ligament ankle sprain recurrences

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Abstract: The ankle joint (talocrural articulation) is a hinge type of synovial joint. It is located between the distal ends of the tibia and fibula and the superior part of the talus. A sprain to the lateral ankle occurs when the lateral ligaments are exposed to a stretching force that exceeds their tensile strength. The recurrence rate for lateral ligament ankle sprains has been reported to be as high as 80%. Current research shows that complex interactions between altered joint mechanics and functional control patterns result in chronic instability of the ankle. X is a 27 year old female who 3 weeks ago sustained an inversion ankle sprain during a surfing lesson. On further questioning X reports a history of chronic ankle instability. Her BASI Pilates program has been devised to improve ankle stability and range of motion. It also aims to holistically build knowledge and strength in regards to postural muscles and proprioception.
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Anatomy and Biomechanics of the Ankle Joint

The ankle joint (talocrural articulation) is a hinge type of synovial joint. It is located between the distal ends of the tibia and fibula and the superior part of the talus. The distal ends of the tibia and fibula form the medial and lateral malleoli respectively.

The malleoli grip the talus tightly as it rocks anteriorly and especially posteriorly. The joint connecting the distal tibia and fibula is a fibrous joint (syndesmosis). The integrity of this articulation is essential for the stability of the ankle joint because it keeps the lateral malleolus firmly against the lateral surface of the talus. The principle connection between the tibia and fibula is a strong interosseous ligament, the distal continuation of the interosseous membrane. Anterior and posterior inferior tibiofibular ligaments also strengthen the joint. Slight movement of the distal tibiofibular ligament occurs to accommodate the talus during dorsiflexion of the foot.

The grip of the malleoli on the trochlear of the talus is strongest in dorsiflexion of the foot because the movement is limited by the strong aforementioned interosseous ligament and the anterior and posterior tibiofibular ligaments. Relatively in plantar flexion the ankle joint is unstable because the trochlea of the talus lies loosely in the ankle mortise. It is during plantar flexion that most injuries of the ankle occur, usually as a result of sudden, unexpected inversion of the foot.

The ankle joint has a fibrous capsule that is thin anteriorly and posteriorly but strengthened laterally by strong collateral ligaments. The lateral ankle ligament is weaker than the medial ligament and consists of three parts:

- Anterior talofibular ligament – a flat weak band extending anteriomedially from the lateral malleolus to the neck of the talus
- Posterior talofibular ligament – a thick fairly strong band extending horizontally, medially and slightly posteriorly from the malleolar fossa to the lateral tubercle of the talus
• Calcaneofibular ligament – a round cord that passes posterioinferiorly from the lateral malleoli to the lateral surface of the calcaneus.

The strong **medial ligament** (deltoid ligament) has four parts fanning out from the malleolus and attaching distally to the talus, calcaneus and navicular. They are named the tibionavicular, anterior and posterior tibiotalar ligaments and the tibiocalcaneal ligament. The medial ligament stabilizes the ankle during eversion and prevents partial dislocation of the joint.

**Movements of the Ankle**

Muscles in the anterior compartment of the leg produce **Dorsiflexion** of the ankle. Dorsiflexion is usually limited by the passive resistance of the triceps surae (gastroc’s and sloeus collectively) to stretching and by tension in the medial and lateral ligaments. **Plantar flexion** of the ankle is produced by the muscles in the posterior compartment of the leg. The many joints of the foot involve tarsals, metatarsals and phalanges. The important inter tarsal joints are the calcaneocuboid, talonavicular and the subtalar joints. **Inversion** and **Eversion** of the foot are the main movement involving these joints. All foot bones are united by dorsal and plantar ligaments.

**Incidences**

The recurrence rate for lateral ligament ankle sprains has been reported to be as high as 80%. A sprain to the lateral ankle occurs when the lateral ligaments are exposed to a stretching force that exceeds their tensile strength. Landing awkwardly from a jump or during running, over reaching for a ball in tennis or tripping over an unseen obstacle are commonly reported mechanisms of injury. The mechanism of recurrent sprains is similar to the initial incident, why people go on to suffer chronic instability continues to be researched.
Chronic Instability: Contributing Structural and Functional Factors

Structural abnormalities contributing to repeated episodes of ‘giving way’ is described as mechanical instability and can include the following:

Pathological Ligament Laxity; ligaments can be known to heal in a lengthened state post ankle injury. This may leave the ankle complex mechanically instable. The talocrural joint in the most commonly involved however instability has also been seen at the subtalar joint. Abnormalities in Joint Movement; namely a restriction in dorsiflexion movement after a sprain is thought to limit the ankle’s ability to reach a fully close-packed (stable) position during standing leaving it vulnerable to repeated inversion stresses. In some cases partial displacement of the tibia at the lower tibiofibular joint may also mean that the peroneal muscles no longer have a firm base from where they can stabilize the ankle dynamically. Synovial inflammation and degenerative joint changes; these have both been found in chronic ankle instability cases and can contribute to impingement, however it is not know if these findings are cause or effect of repeated ankle sprains.

When ankles continue to sprain and no specific mechanical cause is identified it is termed Functional Instability. Functionally altered proprioception, postural control and neuromuscular control are notable factors. Functionally altered proprioception occurs post-lateral ankle sprain; this impairs the body’s ability to prepare the joint for activity. Decreased neuromuscular and postural control leads to altered motor control patterns. This can cause compensations at the knee and ankle resulting in an immobile and therefore brittle ankle joint. The body compensates by reducing knee flexion and ankle dorsi flexion during walking and landing from jumps. The body’s instinct is to reduce movement at the ankle joint as a form of protection. This however is undesired and is a considerable factor in chronic instability. Proprioceptive defects include:

- Errors in detecting ankle position prior to ground contact
- Failure to accurately replicate passively positioned joint angles
• An inability to set appropriate muscle force levels to provide joint stability prior to landing from a jump

The bodies Postural Control System aims to maintain postural equilibrium during all activities. There is evidence to suggest that the body alters its postural control motor patterning after repeated ankle sprains, in an effort to preserve balance. The precise reason for loss of postural control with chronic ankle instability is unique to each different case.

Neuromuscular Control relates to an athletes/persons ability to preemptively stabilize the ankle joint before ground contact, thus reducing avoiding excessive joint movement upon contact. It takes more time for the CNS to control the appropriate muscles than it does for the ankle to reach maximum inversion. The peroneal muscles are the muscle group required to resist the wobble at the ankle joint upon impact. The peroneals appear to be better at preparatory stability than at reactive stability. Evidence is suggesting that with chronic ankle instability their anticipatory muscle action of the peroneals has been lost.

Results of Structural and Functional Compensations
Interactions between altered joint mechanics and functional control patterns result in chronic instability of the ankle, however at present research has not yet ascertained the precise nature and interaction of all the contributing factors. What we do know it that in order to maintain function and performance the body alters its motor control patterns to compensate for its mechanical failings. This results in reduced amount of knee flexion when landing from a jump and reducing dorsiflexion. The brain believes that by making the ankle more rigid it is making it safer but in actual fact this makes the ankle brittle and less able to attenuate landing forces, which ultimately ends in further injury. The resulting reduction in dorsiflexion seen in chronic ankle instability can place greater biomechanical demands on the body that can increase the risk of developing an overuse injury.
Case Study

Name: X
Age: 27 female
3 weeks ago sustained inversion ankle sprain during surfing lesson; jumped off board in the shallows and inverted L ankle.

Initial treatment consisted of RICE for 2 days after injury. X was able to stand and walk on the injured ankle after the event there was evidence of swelling over the lateral aspect of the ankle and limited range of motion through dorsi and plantar flexion but no bruising. It was ascertained by these finding that X had sustained a minor (grade 1) ankle sprain. Standard prognosis for this kind of injury is 1-2 weeks.

On further questioning X reported similar events happening over the last 7 years or so. The first event happened during a netball game, it was worse in severity than this event; X recalls a diagnosis of grade 2 sprain. She goes on to report at lease 1 – 2 ankle sprains of her left ankle per year since.

For the initial ankle sprain X underwent a standard physiotherapy rehabilitation program working through initially RICE followed by proprioception and range of motion exercises, streamline walking then running. Then progressing to plyometric and agility exercises. She was given home exercises to improve dorsiflexion and also used a wobble board for about 1 month after the injury.

Pain and swelling reduced following this program so X stopped her exercises and continued with daily life. The subsequent ankle sprains were not as severe and she managed them herself w RICE. However over the last year there has been mild swelling over the L ATFL.
X has attended 2 sessions with her Osteopath since this most recent ankle sprain. Treatment has focused on improving range of motion through the L talocrural joint and the L superior tibular-fibular joint. Also releasing the gastroc and peroneal muscles and treating gait compensations. X has reduced ROM through her hips and has a tendency to get mild R sacroiliac pain. X reports her ankle pain to be all but gone and she is really keen to try some Pilates to help prevent further ankle sprains and also improve her overall core stability. Apart from the ankle X has no other limitations for Pilates, she swims 2 times a week and walks to work every day (20 min walk) and therefore has a reasonable level of aerobic fitness.

**BASI Pilates Program:** As X is a beginner to Pilates we will start with the basics. Spinal Articulation and FBI 1 are traditionally not introduced into the repertoire until at least 10 Pilates sessions in keeping with the progressive layering aspects of the BASI block system. Therefore they have not been included for initial classes but will be listed as optional progressions. To enable flow through the session the blocks have been moved around from their traditional order. Desired results from this program include:

- Improved ankle proprioception
- Strengthening to the peroneals, gastrocs and hamstring muscles
- Improved hip abduction and therefore lumbar stability
- Strengthen core
- Upper body strength and control which will be especially good for surfing

**Warm up: MAT**

Roll Down
Find Neural Pelvis and Neutral Spine in Supine Position
Pelvic Curl
Chest Lift
Single Leg Lifts and Leg changes
Leg Circles
Roll up
Footwork: REFORMER
Parallel heels
Parallel toes
Small V
Wide heels
Wide toes
Calf raises
Prances

Rationale: Pilate’s footwork is an excellent opportunity for X to train her brain. It simulates walking but without the full force of gravity and with an added visual cue. X will be able to view her feet throughout the footwork. We will be looking for asymmetries, any excessive inversion or eversion and also cueing pelvic lumbar stability throughout. A mobile ankle is the desired result however if there is any pain we will not force the dorsiflexion because if too early it can re-irritate the joint capsule.

Abdominals: REFORMER
Hundred Prep
Co-ordination
Rationale: In 1998/9 the University of Queensland (Hodges and Richardson) found that delayed activation of the Transverse Abdominus muscles during arm or leg motions was present in Low back pain patients when compared to asymptomatic people. More recent research shows that many muscles with different muscles taking a greater role depending on the movement challenge achieve lumbar spine stability. Kavic et al 2004. Abdominal bracing has been shown to stabilize the spine and reduce axial rotation during leg motions. There is also specific research supporting reduced risk of knee injury when the subject has adequate core strength and that training the core helps with rehabilitation for recurrent hamstring injury athletes. X like many others will benefit from Abdominal focused core exercises particularly specific Pilates exercise emphasizing stability and precision of movement.
Hips: CADILAC Basic Leg Springs

- Frog
- Circles (Down, Up)
- Walking
- Bicycles

*Rationale:* Treating the biomechanical source of the pain instead of the site of the signs and symptoms is based on a concept called regional independence. It is a theory that dysfunction in one area is responsible for dysfunction in another. Reduced hip abduction has been shown to contribute to lower back pain that occurs with prolonged standing. Unilateral hip deflection has also been shown to be linked with SIJ pain. Improving range of motion through X’s hips may help with her lower back pain. Also working up through the kinetic chain will help with biomechanical compensations associated with the X’s chronic ankle instability.

Arms: REFORMER: Arms Sitting Series

- Chest Expansion
- Biceps
- Rhomboids
- Hug-A-Tree
- Salute

**Back Extension: REFORMER**

- Breaststroke Prep

*Rationale:* A fundamental Back extension exercise from the Long Box series. Focusing on strengthening the upper back extensors and improving scapula stabilization. This is a good exercise to simulate the position while paddling on a surfboard. It will be a good opportunity to ensure head and neck position are correct and also a good opportunity to
cue abdominal engagement throughout the exercise. We can also work on continuing to
breath through the exercise.

Extension exercise will finish with child’s pose stretch.

**Additional leg work: WUNDA CHAIR**

Leg Press Standing and Forward Lunge

*Rationale: Leg press standing will be a good opportunity to work on balance, quadriceps
control and hip extensor strength. It is a holistic exercise also working on pelvic stability.*

**Lateral flexion / Rotation: WUNDA CHAIR**

Side Stretch

**Stretches: POLE Series while seated on the Wunda chair**

Shoulder stretch
Overhead stretch
Side stretch
Spine twist

**Roll down to complete the class.**

**PROGRESSIONS:**

**Full Body Integration 1:** Elephant (up stretch series on the reformer) requires a
significant amount of dorsiflexion while the heels are kept firmly on the reformer bed,
provided no pain or impingement is experienced this will aim to improve and maintain
dorsiflexion. The other exercises in the up stretch series and also the stomach massage
exercises will also be good to build and maintain ankle stability.
**Spinal Articulation:** Keeping with the aforementioned program Spinal articulation can be incorporated after hip work on the Cadillac. Money original and tower prep will train abdominal control, aid in spine stretching and mobility and also provide a hamstring and calf stretch.

**Footwork** progressions will also occur. We will progress to the wunda chain and teach X to maintain ankle stability, symmetry and precision in an up right position. Footwork on the Cadillac is also a good alternative with again the invaluable visual cue.

In terms of **additional legwork**, after X has improved on key Pilates principles and techniques such as pelvic lumbar stabilization we will progress to the foot platform series on the reformer. With the head rest raised it will be an excellent opportunity to gain visual input during jumping particularly learning to articulate through the foot throughout take off and landing. This will also add a plyometric aspect to her workout.

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**Conclusion:** An ankle sprain is a very common injury both in the sporting and general population. Once initial pain and swelling has subsided thorough rehabilitation is uncommon and therefore leads to 80% of lateral ankle sprains reoccurring. Structural ligament instabilities altered joint movements, functional proriception, motor and neuromuscular control patterns can all contribute to this instability. Developing a holistic and effective conditioning program using the BASI Pilates block system aims to improve the aforementioned structural and functional dysfunctions when they are present. It also aims to build a mind-body form of conditioning in to the learning and re-education process of movement.
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