17

Examination of the Foot and Ankle

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LEARNING OUTCOMES

After studying this chapter, you should be able to:

- Outline the anatomy and key functions of the foot and ankle complex.
- Discuss common pathological presentations for this region.
- Outline pertinent comorbidities and conditions which may affect the foot and ankle region.
- Describe the subjective and physical assessment for this region.
- Using clinical reasoning, justify the selection of tests and interpretation of findings related to common pathological presentations of the foot and ankle.

CHAPTER CONTENTS

INTRODUCTION TO THE FOOT AND ANKLE COMPLEX

Anatomical and Functional Overview

The foot and ankle normally consist of a complex of 28 bones (tibia, fibula, calcaneus, talus, navicular, cuboid, medial/intermediate/lateral cuneiforms, 5 meta-tarsals, 14 phalanges), a variable number of sesamoids, with 34 joints and over 100 muscles, tendons and ligaments, all supplied by three different peripheral nerves—the tibial, common peroneal and saphenous. The main blood supply for the area originates from the peroneal, posterior tibial and anterior tibial arteries. Anatomically the foot is classically divided into the forefoot, midfoot and hindfoot, with specific joints associated with each area (Table 17.1).

Function

The foot and ankle form part of the whole-body kinetic chain and combine flexibility with stability to facilitate two principal functions: propulsion and support. For propulsion, the foot and ankle act as a complex flexible lever; for support, it acts as a rigid structure that supports the entire body weight. Aligned with these functions the foot and ankle must also adapt to uneven terrain and act as a shock absorber during the gait cycle as well as provide sensory information for balance (Nyland et al., 2018).

Foot and Ankle Dysfunction

There are many musculoskeletal (MSK) pathologies that can impact on the normal function of the foot and ankle; symptoms can arise from local anatomical sources, can be referred from other areas of the body or may be the result of systemic or genetic conditions. Trauma is common and can be problematic; for example, the reported pooled prevalence of lateral ankle sprains (LAS) is 11.88% in the general population (Doherty et al., 2014), and LAS can cause (amongst other injuries) fractures of the lateral malleolus, fractures of the fifth metatarsal, osteochondral defects of the talus, disruption of the inferior tibiofibular joint and lateral ligamentous complex with resultant ankle instability (Miller et al., 2017). Patients with foot and ankle dysfunction can also present with tendinopathies associated with acute overload or degenerative changes such as tibialis posterior tendon dysfunction or mid-substance/insertional Achilles tendinopathy (Chimenti et al., 2017; Ling & Liu, 2017). Neural tissue sensitization can be associated with trauma, surgery, increased pressure, degenerative changes or entrapment; examples of this include tarsal tunnel syndrome and Morton's neuroma (Pomeroy et al., 2015). Other insidious-onset conditions, such as plantar fasciopathy and osteoarthritis can significantly impact activities of daily living, whilst systemic inflammatory conditions, such as rheumatoid arthritis (RA), ankylosing spondylosis (AS) and gout, can also result in pain and deformities (Helliwell et al., 2019). Metabolic disorders such as diabetes may affect the foot, causing peripheral neuropathy, vascular compromise and specific disease such as Charcot disease (Dewi & Hinchcliffe, 2020). Hereditary predisposition to certain conditions is recognized, including a familial link to hallux valgus and lesser-toe deformities (Hannan et al., 2013). Less commonly encountered upper motor neuron and lower motor neuron conditions, such as traumatic brain injury, stroke, spinal cord injury, cerebral palsy and Charcot–Marie–Tooth disease, can also have a significant impact on foot and ankle function. These examples are by no means exhaustive but highlight the diversity of conditions which can affect the region. In recognition of the foot and ankle's functional significance and complexity patients with specific conditions (or postsurgery) may be managed by a dedicated foot and ankle therapy team which could include orthopaedic doctors, physiotherapists, chiropodists, podiatrists, nurses and radiologists.

TABLE 17.1 Functional Units of the Foot

Rearfoot	Midfoot	Forefoot
Talocrural joint	Talonavicular joint	Tarsometatarsal joints
Subtalar joint	Calcaneocuboid joint	Metatarsophalangeal joint
		Interphalangeal joints

A thorough knowledge of functional anatomy and biomechanics will inform clinical reasoning, ensuring the initial examination is efficient and management strategies seek to optimize all aspects of functional restoration.

KNOWLEDGE CHECK

1. What are the four key functions of the foot and ankle?
2. Name the main joints which make up the foot and ankle complex.
3. Name the three main nerves and arteries which supply the foot and ankle complex.
4. Name four common musculoskeletal conditions that can affect the foot and ankle.
5. Name four health care professions commonly involved with the management of patients with foot and ankle conditions.

SUBJECTIVE EXAMINATION/TAKING THE PATIENT'S HISTORY

This chapter will focus on questions asked and tests utilized in the physical examination of the foot and ankle complex; these should be individualized to the patient. Details on the principles of the subjective and physical examinations can be found in Chapters 3 and 4, respectively.

Patient's Perspectives on Their Experience

Most patients will seek treatment because they have symptoms and/or functional limitations which are impacting their activities of daily living, for example, pain, paraesthesia, swelling and/or difficulty with weight-bearing activities. Sometimes patients experience difficulty finding comfortable footwear or the aesthetic appearance of the foot alone or in combination with other symptoms is troublesome, this may affect the patient's psychological well-being. Examples of this include progressive hallux valgus or claw/hammer-toe deformities (Souza Júnior et al., 2020) (Fig. 17.1).

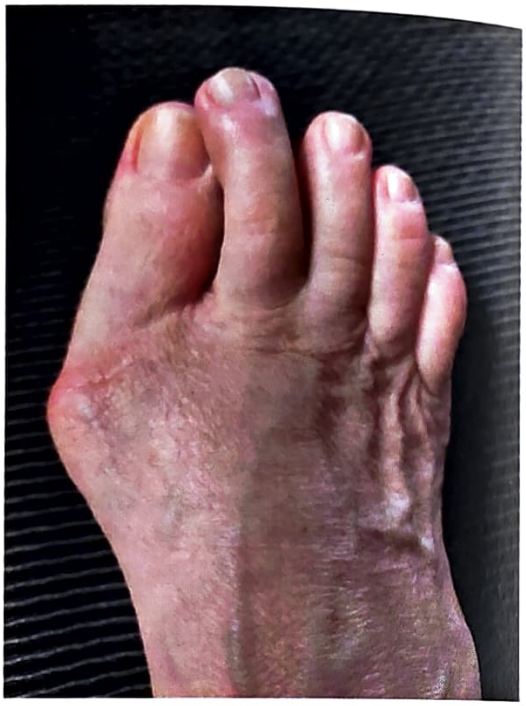


Fig. 17.1 Right hallux valgus with associated lesser toe deformity.

Outcome Measures

There are a number of self-reported outcome tools that can be used to measure patients' perception of disability, the impact of symptoms/surgery on function and to measure the effect of interventions over time, e.g.

- American Orthopaedic Foot and Ankle Score (AOFAS)
- Foot and Ankle Ability Measure (FAAM)
- Foot and Ankle Disability Index (FADI)
- Foot Function Index (FFI)
- Foot Health Status Questionnaire (FHSQ)
- Lower Extremity Function Scale (LEFS)
- Manchester-Oxford Foot Questionnaire (MOFQ)

See Shazadeh Safavi et al. (2019) and Jia et al. (2017) for an overview of the properties of these and similar outcome measures.

Social History

Social history that is relevant to the onset and progression of the patient's problem is important to explore. For example, an increased training load may result in symptoms related to conditions such as plantar fasciopathy or Achilles tendinopathy (Martin et al., 2014; Silbernagel et al., 2020). Early identification of psychosocial and behavioural risk factors is important as these may play a role in the development of symptoms and persistent disability. For example, chronic alcohol consumption can result in foot and lower limb

paraesthesia/anaesthesia, pain, hyporeflexia, reduced proprioception and gait ataxia (Thomas et al., 2019), whereas smoking and depression have been linked to the development of chronic regional pain syndrome following elective foot surgery (Rewhorn et al., 2014).

Body Chart

The following information concerning the type and area of current symptoms can be recorded on a body chart (see Fig. 3.2 for an example of a typical body chart).

Area of Current Symptoms

Be exact. It is often useful to ask the patient to use one finger to point to the location of predominant symptoms. Dysfunction in the foot and ankle tends to produce local symptoms and follow recognizable patterns. For example, with stress fractures of the foot and lower limb, the area of pain tends to be localized, can be exercise-induced and improves with rest (Welck et al., 2017), whilst plantar fasciopathy is the most common cause of medial plantar heel pain, is often worse on initial weight bearing after periods of rest and can get worse with prolonged weight-bearing activities (Martin et al., 2014).

Areas Relevant to the Region Being Examined

Symptoms in the foot and ankle may be referred from more proximal sources such as the lumbosacral spine, sacroiliac and hip structures (Slipman et al., 2000; Lesher et al., 2008; Nelson & Hall, 2011). Symptoms may also arise as a result of poor proximal control of the pelvis, hip or knee or as a result of dysfunctional foot biomechanics, which may result in compensatory pathological loads on tendons at the foot and ankle (Sueki et al., 2013).

Quality of Symptoms

The quality of symptoms informs clinical reasoning; paraesthesia supports a hypothesis of neural tissue dysfunction, especially if associated with burning, shooting or electric shock-type pain (Pomeroy et al., 2015). Following LAS, functional or mechanical ligamentous instability may result in 'giving way' of the ankle, ankle stiffness and complaints of weakness (Remus et al., 2018; Hertel & Corbett, 2019). Descriptions of stiffness and locking may indicate degenerative changes, for example, hallux rigidus of the first metatarsophalangeal joint (MTPJ) or OA of the talocrural joint (Adukia et al., 2020; Chan & Sakellariou, 2020). Prolonged joint stiffness, especially in the morning, may indicate systemic disorders particularly if associated with other signs and symptoms of inflammatory/reactive disease, e.g. RA, Reiter's, gout, psoriasis, AS (NICE, 2017). It is important to check for any altered sensation such as paraesthesia, anaesthesia, hypoaesthesia, hyperaesthesia and allodynia throughout the lower limb and locally around the foot. The distribution of any sensory changes will help to differentiate between dermatomal distribution from spinal nerve roots, symptoms of peripheral nerve origin and upper motor neuron lesions (see Chapter 3). For example, bilateral paraesthesia/anaesthesia in both hands and feet associated with weakness/heaviness in the legs, difficulty walking and difficulties with fine-motor activities, e.g. writing, could indicate the serious condition of cervical myelopathy (Cook & Cook, 2016).

Determine whether symptoms are felt on the surface or deep inside. Deep anterolateral or anteromedial ankle pain after LAS in conjunction with pain on weight bearing may indicate the presence of an osteochondral lesion, whilst more superficial symptoms may support purely soft-tissue involvement (Wodicka et al., 2016; Kerkhoffs & Karlsson, 2019).

Intensity of Pain

The intensity of pain can be measured (as explained in Chapter 3) and contributes to clinical reasoning of severity, alongside the use of analgesic medication, sleep disturbance and limitation in activities. Severity and irritability will guide the extent and vigour of the physical examination.

Constant or Intermittent Symptoms

Ascertain the frequency of symptoms. Progressive unremitting pain may require investigation to exclude serious pathology such as neoplastic disease (Kennedy et al., 2016; Darcey, 2017). Whilst cancer is uncommon in the foot and ankle constant pain may indicate inflammatory disorders such as gout and RA (NICE, 2017). Incapacitating pain associated with sensory, motor, vasomotor and/or trophic changes, could highlight the development of chronic regional pain syndrome, which can be a complication following fractures, minor injury and surgery (Kim, 2016; Cowell et al., 2019).

Relationship of Symptoms

If the patient has proximal and distal symptoms, determine the relationship between the areas. This information will assist with reasoning the most likely source of symptoms and so focus the physical examination.

Behaviour of Symptoms

Aggravating Factors

For each symptomatic area, ask what functional activities, movements and/or positions aggravate the patients' symptoms, if they are able to maintain an activity or position or whether they have to stop (severity)? How long does it take for symptoms to ease once the position or movement is stopped (irritability)? Irritability and severity are explained in Chapter 3. The clinician should clinically reason how symptoms impact function and lifestyle. For example, patients with Morton's neuroma or hallux valgus tend to dislike tight, narrow shoe wear and prefer to be barefoot or use flipflops, etc. (Alrabai et al., 2016). Validated clinical prediction rules are useful to diagnose specific pathologies. For example, anterolateral ankle impingement demonstrates the following features: anterolateral joint tenderness and recurrent swelling, pain with forced dorsiflexion and eversion, pain with single-leg squat, pain with activities and the possible absence of ankle instability (Liu et al., 1997).

Easing Factors

For each symptomatic area, the clinician assesses irritability by exploring what eases symptoms, how long symptoms take to ease and to what extent. Collating this information with a thorough knowledge of specific pathologies and typical presentations helps to refine hypothesis generation, guide further history taking and determine reasoned physical examination. If the patient's symptoms do not fit an MSK presentation, then the clinician needs to be alert to other, possibly more serious causes and refer on.

Behaviour of Symptoms Over Time

How do symptoms behave over 24 hours?

Night symptoms. Whilst night pain may raise suspicions of serious pathology, it is useful to consider alternative hypotheses as well. For example, patients with OA may describe night pain as the disease progresses (Khlopas et al., 2019), and night pain in this group may be one indication for surgery.

Morning and evening symptoms. The clinician determines the pattern of the symptoms throughout the day. Early-morning pain and stiffness for an hour or more may be suggestive of inflammatory conditions such as RA or AS (NICE, 2017). Patients with plantar fasciopathy or tendinopathy describe classic 'start-up' pain on initial weight bearing in the morning which can continue in the day with prolonged weight bearing or repetitive activity (Lancaster & Madhaven, 2021).

Special/Screening Questions and General Health

As discussed in Chapter 3, the clinician must differentiate between conditions that are suitable for conservative treatment and other systemic, neoplastic and nonmusculoskeletal conditions, which may require referral elsewhere. Chapter 3 discusses special questions in detail; hence, only examples relevant to the foot and ankle are highlighted below.

Serious Pathology

Malignant tumours in this area are rare (Kennedy et al., 2016), and the foot and ankle are also atypical sites for MSK tuberculosis; if suspected, patients should be asked about possible exposure to tuberculosis (Faroug et al., 2018).

Osteoporosis

Associations between low bone mineral density and ankle fractures in the elderly have been established (So et al., 2020), and if osteoporosis is suspected the vigour of the physical examination will need to be modified.

Inflammatory Arthritis

Patients should be asked if they or a member of their family has been diagnosed with an inflammatory condition. Overall, the lifetime risk of foot involvement in patients with RA is 90%, and this condition can initially present in the small joints of the feet (Yano et al., 2018; Walker et al., 2019).

Cardiovascular Disease

Does the patient have a history of cardiovascular disease, e.g. hypertension, angina, previous myocardial infarction, stroke? Patients who develop symptoms of peripheral vascular disease may present with intermittent claudication—an aching muscle pain in the calf or foot that is brought on by exercise and rapidly relieved by rest (Spannbauer et al., 2019).

Diabetes Mellitus

The foot and ankle are targets of this complex multisystem disease, which is a result of chronic hyperglycaemia caused by insulin deficiency. The effects of diabetes can manifest from mild neuropathy to severe ulcerations, infections, vasculopathy, Charcot arthropathy, neuropathic fractures and ultimately amputation (Walker et al., 2019; Dewi & Hinchcliffe, 2020). As a result of vascular deficits, tissue healing is likely to be slower. Patients with the disease have been shown to have significantly higher rates of postoperative complication, infection, Charcot arthropathy, nonunion and amputation after ankle fracture compared to patients without diabetes (Lavery et al., 2020). Diabetic neuropathy affecting the feet and hands typically presents with a stocking-and-glove distribution, beginning distally and spreading proximally, and can demonstrate a combination of diminished light touch sensation, proprioception, temperature awareness and pain perception (Oji & Schon, 2013).

Neurological Symptoms If a Spinal Lesion Is Suspected

See Chapter 3 for discussions related to spinal cord compression, cauda equina syndrome and neuropathic pain presentations. Of note, spinal cord compression may also result in bilateral tingling in the hands or feet (Cook & Cook, 2016). Pes cavus (clawing of the feet) can be the result of a number of hereditary, neurological and idiopathic conditions (Seaman & Ball, 2021) but new onset, unilateral progressive pes cavus warrants urgent further neurosurgical investigation as this may indicate the present of a spinal cord or brain tumour (Grice et al., 2016).

Past Medical History

A detailed medical history will identify contraindications and precautions to the physical examination and may help explain the development of current symptoms. For example, a history of endocrine abnormalities, in particular, vitamin D deficiency has been associated with nonunion after elective foot and ankle reconstruction (Moore et al., 2017). Other relevant disorders have been outlined above in special questions and general health.

History of the Present Condition

For each symptomatic area, the clinician asks how long symptoms have been present, whether there was a sudden or slow onset and whether there was a clear cause. If the patient can recall a traumatic onset, such as a fall, closer questioning of the mechanism of injury is imperative. Under the Ottawa ankle rules, patients should be referred for radiographic examination (or other medical imaging) to exclude fractures if they have pain and tenderness in the malleolar area/s, the base of the fifth metatarsal, navicular or an inability to weight bear four steps immediately after injury and when admitted to an emergency department. These rules have a sensitivity of almost 100% and a modest specificity and are used for adults and children over the age of 5 (Beckenkamp et al., 2017). Alternatively, if there has been an insidious onset of symptoms, the clinician questions for change in the patient's lifestyle, e.g. a new job or hobby, or a change in existing sporting activities, including alterations in footwear, equipment, surface or intensity. Sensitively determining recent or chronic weight gain can assess the impact of additional biomechanical stresses; increased body mass index in the nonathletic population has been associated with conditions such as plantar fasciopathy (Martin et al., 2014). The goal is to establish what has happened or to build a picture of what has changed to understand fully why a patient is presenting with symptoms.

Is this the first episode or is there a history of foot or ankle problems? If so, how many episodes? When were they? What was the cause? What was the duration of each episode? Did the patient fully recover between episodes? It may be that injuries sustained years previously are relevant, for example, previous ankle sprains or fractures have been associated with the development of osteochondral lesions and posttraumatic arthritis (Ewalefo et al. 2018; Lee et al., 2021). If there have been no previous episodes, has the patient had incidences of stiffness in the lumbar spine, hip or knee or any other relevant region? In addition, the clinician needs to ask if the patient has sought treatment to date, what it was and whether it helped. What has the patient been told and by whom? What does the patient believe is going on? Collaboratively clarifying the patient's journey can help the clinician to understand the patient's context and inform patient-centred clinical reasoning.

Radiography and Medical Imaging

Has the patient undergone any radiological investigations? Radiographs are the cornerstone of diagnostic imaging and provide an often essential screening

tool for many foot and ankle problems. When trauma is involved the Ottawa ankle rules provide guidelines for patients who should be x-rayed (Beckenkamp et al. 2017). Magnetic resonance imaging (MRI) is used to evaluate soft-tissue pathology of the foot and ankle and is particularly useful for imaging osteochondral lesions, bony and soft-tissue tumours, stress reactions, bone bruising, ligamentous damage, bursitis, fasciopathy, tendinopathy/tendon tears and the diabetic foot (Mohan et al., 2010; Pedowitz, 2012). Ultrasound is used to examine soft tissues, such as tendons, ganglions and neuromas, and is the preferred imaging modality when Morton's neuroma or Achilles tendinosis is suspected (Beard & Gousse, 2018). It is also useful for guiding aspirations and specific injections. Computed tomography (CT) provides rapid imaging to help evaluate complex anatomy and pathology and is used primarily for evaluating bone as opposed to soft tissue. The multiplanar nature of CT enhances its ability to detect disease not appreciable on plain radiographs (Haapamäki et al., 2005). SPECT-CT, a radionuclide bone scan with single-photon emission CT and CT, is a relatively new imaging modality which combines highly detailed CT with the functional information from a triple-phase radionuclide bone scan. SPECT-CT is increasingly recognized as having high diagnostic accuracy and is recommended for use in foot and ankle cases of diagnostic uncertainty and for the evaluation of chronic foot/ankle pain, especially in patients with previous surgery or in-situ metal work (Eelsing et al., 2021).

Other tests may include blood tests, required if systemic inflammatory conditions such as RA, AS or gout are suspected.

Results from additional investigations will provide information to inform clinical reasoning and may help indicate a likely prognosis.

KNOWLEDGE CHECK

1. Name four non-MSK comorbidities which may have an impact on the assessment and management of patients with MSK foot and ankle conditions.
2. Describe how diabetes might affect the foot and ankle.
3. What rules are used to determine if a patient needs an x-ray to exclude fracture in the ankle and midfoot after trauma?
4. How does plantar fasciopathy typically present?

KNOWLEDGE CHECK—cont'd

5. Name four types of medical imaging which may be used in the management of foot and ankle dysfunction and what these are typically used for.

Plan of the Physical Examination

The information from the subjective examination helps the clinician identify an initial primary hypothesis, alternative hypotheses and to plan the physical examination. The severity, irritability and nature of the condition are key factors that influence the choice and priority of physical testing procedures. Initially, the clinician might ask: 'Is this patient's condition suitable for me to manage as a therapist?' For example, a patient presenting with progressive unilateral pes cavus symptoms may only need neurological testing prior to an urgent medical referral. Hence the nature of the patient's condition has a major impact on the physical examination. Following this, the clinician might question: 'Does this patient have a musculoskeletal dysfunction that I may be able to help?' To answer that, a full physical examination is required; however, this may not be possible if the symptoms are severe and/or irritable. If this is the case, the clinician aims to explore movements as much as possible, within a symptom-free range. If the patient has constant and severe and/or irritable symptoms, then it is wise to use physical tests that ease symptoms; it may be that the patient will require rest periods between tests to avoid build-up in symptoms. Alternatively, for patients with symptoms judged to be of low severity and irritability, physical testing will need to be more searching and may require the use of overpressures, and repeated and combined movements to reproduce symptoms. In addition to symptom reproduction and easing, contributing factors such as foot posture and biomechanics may need to be examined for relevance. A planning form can help guide the clinician's reasoning in the selection of physical examination procedures (see Fig. 3.7). An understanding of the sensitivity and specificity (see Chapter 4) of the tests applied should also be considered so that findings can be interpreted appropriately. Each significant physical test that either provokes or eases the patient's symptoms is highlighted in the patient's notes by an asterisk (*) for easy reference. The clinician needs to have a clear clinical hypothesis after

the subjective examination, the purpose of the physical examination is to confirm or refute this hypothesis.

It is important for readers to understand that the physical examination approaches included in this chapter are some of many and that those chosen are clinically useful and include an indication of their level of support in the literature.

PHYSICAL EXAMINATION

Observation

Informal Observation

Throughout the subjective and physical examination, the clinician notices the patient's behaviours. Has the patient been able to weight bear easily on the foot and ankle coming into the clinic, what footwear is being used, is the patient distressed, etc.?

Formal Observation

Observation of posture. The patient should be suitably dressed so that the clinician can observe the patient's bony and soft-tissue contours in standing and non-weight bearing, noting the posture of the feet, lower limbs, pelvis and spine. General lower-limb abnormalities include uneven weight bearing through the legs and feet, internal femoral rotation and genu varum/valgum or recurvatum (hyperextension). It is worth noting whether the foot has a particularly flattened or exaggerated medial longitudinal arch, as these may indicate pes planus or pes cavus respectively. The toes may be deformed, for example, claw toes, hammer toes, mallet toes and hallux valgus/rigidus. Further details of these abnormalities can be found in a standard orthopaedic textbook (Thordarson, 2013; Magee, 2021).

Observation of foot and ankle alignment. Impaired alignment of the foot and ankle may result in suboptimal movement patterns, impacting on function. Multiple theories and approaches to the assessment of foot and lower-limb biomechanics have developed over time (Root et al., 1977; Dananberg, 1986; McPoil & Hunt, 1995; Kirby, 2001; Vicenzino, 2004; Redmond et al., 2006; Fuller & Kirby, 2013). Preferencing one method over another is controversial (Kirby, 2015; Harradine et al., 2018); however, it is useful when beginning to assess foot and ankle biomechanics to use a systematic approach.

The Foot Posture Index (FPI) (Redmond et al., 2006) is one such approach and consists of six validated, criterion-based observations of the rearfoot and forefoot with a patient standing in a relaxed position. The rearfoot is assessed via palpation of the head of the talus, observation of the curves above and below the lateral malleoli and the extent of the inversion/eversion of the calcaneus. Observations of the forefoot consist of assessing the bulge in the region of the talonavicular joint, the congruence of the medial longitudinal arch and the extent of abduction/adduction of the forefoot on the rearfoot. The FPI has demonstrated concurrent and internal construct validity as well as high intra-rater reliability and moderate interrater reliability (Redmond et al. 2006; Keenan et al., 2007; Fraser et al., 2017), and results in a score between −12 and +12 (where −12 indicates a highly supinated foot posture and +12 indicates a highly pronated foot posture; normative values of +4 in the adult population have been suggested) (Redmond et al., 2008). Research has linked FPI scores to lower-limb pathologies such as medial compartment knee OA, hip OA, chronic plantar heel pain, medial tibial stress syndrome and midfoot OA (Yates & White, 2004; Irving et al., 2007; Reilly et al. 2009; Levinger et al., 2010; Lithgow et al., 2020), although this relationship is unclear and not fully established (Neal et al., 2014). The use of such tools can assist clinicians in supporting or refuting clinically reasoned hypotheses, communicating with colleagues, educating patients and can assist in management decision making such as the use of/referral for orthotics.

Observation of muscle form. The clinician observes the muscle bulk and muscle tone of the lower limb, comparing the left and right sides for relevant differences, remembering that level and frequency of physical activity as well as leg dominance may produce differences in muscle bulk between sides.

Observation of soft tissues. The clinician observes the quality of the patient's skin, any area of swelling, redness, exostosis, callosities or presence of scarring or infection.

Common observations in the foot and ankle include the following:

- pes planus (flatfoot)
- pes cavus (high arch)
- hallux valgus: valgus alignment of the hallux at the MTPJ with prominent medial eminence ± pronation

of the big toe. Often referred to as a 'bunion' (see Fig. 17.1)
- hallux rigidus: OA of the first MTPJ which may result in palpable bony osteophytes over the dorsal aspect of the first MTPJ
- hammer-toe deformity: affecting the lesser toes, the proximal interphalangeal joint has a flexion contracture with secondary extension at the MTPJ and distal interphalangeal joint. Can be fixed or flexible
- claw-toe deformity: affecting the lesser toes, the MTPJ is hyperextended, with flexion contracture at the proximal interphalangeal and distal interphalangeal joints. Can be fixed or flexible
- mallet-toe deformity: flexion contracture of the distal interphalangeal joint. Can be fixed or flexible
- bunionette (tailor's bunion): characterized by the prominence of the lateral aspect of the fifth metatarsal head and medial deviation of the fifth toe at the MTPJ, often with associated callus
- Haglund's deformity: a bony exostosis located on the posterolateral or posteromedial aspect of the calcaneus. Aetiology is unclear but may be the result of overuse, hereditary factors or biomechanical stresses (Vaishya et al., 2016)
- fusiform swelling locally in the Achilles tendon may indicate a reactive tendinopathy (Cook et al., 2016), usually observed in the midportion of the Achilles tendon.
- intractable plantar keratosis (IPK): hyperkeratotic tissue proliferation (callus) on the plantar aspect of the foot, usually under the metatarsal head(s), occurs as a result of excessive mechanical load.
- posteromedial pitting oedema along the course of the tibialis posterior: this observation has been associated with tibialis posterior tendon dysfunction; a condition more common in mid to later-aged women often with comorbidities (DeOrio et al. 2011; Ross et al., 2018)
- adult acquired flatfoot deformity: secondary to tibialis posterior tendon dysfunction, this ranges from a flexible deformity to a rigid deformity with advanced arthritis. Clinical observations can include hindfoot valgus, medial arch collapse, forefoot abduction with 'too-many-toes' sign and inability to perform double and single heel-rise tests (Zaw & Calder, 2010; Ross et al., 2017).
- oedema as a result of trauma/ankle sprain—swelling observed proximally to the ankle mortise may indicate syndesmotic injury of the inferior tibiofibular joint, whereas swelling distal to the lateral malleolus may indicate a lateral ligament complex injury, although this may spread into the foot if the capsule has been damaged (Dubin et al., 2011)

Functional Testing

Functional testing can be carried out early in the examination. Clues for appropriate tests can be obtained from the subjective examination, particularly aggravating factors; these might include activities such as walking, ascending/descending stairs, squatting, walking on uneven surfaces, hopping or running.

Observation of Gait

Gait analysis is important. Observe gait in a logical manner from head to toe, or vice versa, observing each body segment for variations in the normal range. Look for asymmetries, e.g. uneven arm swing, trunk rotation, stride length and differences in weight bearing. Each variation may indicate tight musculature, structural anomalies or functional movement patterns which may have altered through habit or dysfunction. The gait cycle is defined as 'the time interval between two successive occurrences of one of the repetitive events of walking' (Whittle et al. 2012, p. 32). The gait cycle consists of the following events:

1. initial contact (often heel strike)
2. opposite toe-off
3. heel rise
4. opposite initial contact
5. toe-off
6. feet adjacent
7. tibial vertical
8. initial contact—the gait cycle begins again.

The angle of heel contact with the ground is usually slightly varus. Marked variations from this may cause abnormal foot function, with compensation attained either across the midtarsal joint and first and fifth rays or more proximally in the ankle, knee and hip joints. Early heel lift may indicate tight posterior leg muscles which can be a cause of functional ankle equinus (Pascual Huerta, 2014), where the range of dorsiflexion required for normal gait is lacking.

The degree of pronation of the foot during midstance is noted. Pronation is a normal part of gait that allows the foot to become a shock absorber and mobile adapter. Prolonged pronation or failure/delayed

supination of the subtalar joint during mid to late stance (often indicated by a prolonged or rigid valgus of the calcaneum and collapse of the medial longitudinal arch) may indicate tibialis posterior tendon dysfunction (Zaw & Calder, 2010; Stein & Schon, 2015). At heel lift the foot changes to a more rigid lever for toe-off. Limitation of normal function at the MTPJs may affect toe-off and result in more proximal compensations (Nix et al. 2013).

Active Physiological Movements

Active physiological movements of the foot and ankle and possible modifications are shown in Table 17.2. Movements can be tested with the patient in prone, supine or sitting with the right and left sides compared. The range of movement for the foot and ankle can be measured using a goniometer. For active physiological movements, the clinician notes the following:

- willingness of the patient to move
- range of movement available
- quality of movement, e.g. coordination, muscle activation patterns
- behaviour of pain through the range of movement.

Active movements with overpressure to the foot and ankle are shown in Fig. 17.2. Overpressure at the end of the range can be applied to the whole foot. For differentiation purposes, the foot may be considered in functional units: the rearfoot, midfoot and forefoot (see Table 17.1). Using a knowledge of the joint lines the various regions may be individually examined with localized overpressure at the end of the range. The clinician establishes the patient's symptoms at rest, prior to each movement, and notes the effect of passively correcting any movement deviation to determine its relevance to the patient's symptoms.

TABLE 17.2 Active Physiological Movements and Possible Modifications

Active Physiological Movements	Modifications
Ankle dorsiflexion	Repeated
Ankle plantarflexion	Speed altered
Inversion	Combined, e.g.
Eversion	• Inversion with plantarflexion
Metatarsophalangeal	Compression or distraction
• Flexion	Sustained
• Extension	Injuring movement
Interphalangeal joints:	Differentiation tests
• Flexion	Function
• Extension	

Passive Physiological Movements

All of the active movements can be examined passively with the patient in prone with the knee at 90 degrees flexion, or supine with the knee flexed over a pillow, comparing the left and right sides. Comparison of the response of symptoms/range of movement to the active and passive movements can help to determine whether the structures contributing to symptoms/restriction are noncontractile (articular) or contractile (myogenic).

Weight-Bearing Lunge Test

This is a test to measure the range of functional dorsiflexion of the ankle joint. The patient is in weight-bearing and is asked to place one foot perpendicular to a wall, and then lunge the ipsilateral knee to the wall, keeping the hips in a neutral position. The foot is then progressively moved away from the wall until the knee barely touches the wall; however, the foot should remain flat to the floor, without the heel lifting and should not deviate laterally or medially (Fig. 17.3). The distance from the wall to the big toe is then measured in centimetres. Left and right sides are compared for differences; normative studies on healthy adults suggest a 2 cm or greater lunge distance asymmetry can delineate subjects with clinically relevant impairments in ankle/subtalar dorsiflexion (Hoch & McKeon, 2011). Research also indicates this test is both reliable and valid and has reasonable responsiveness to detect a true change in range of motion (Powden et al., 2015; Hall & Docherty, 2017).

Joint Integrity Tests

Osseous congruency, static ligamentous and capsular restraints and myofascial structures are the major contributors to stability at the ankle. LAS are the most common injury, followed by syndesmotic disruption and then medial ankle sprain (Doherty et al., 2014), with significant rates of persistent symptoms and disability following acute ankle sprain (Martin et al., 2021). LAS consist of partial or complete disruption of the lateral ankle ligaments (anterior talofibular ligament

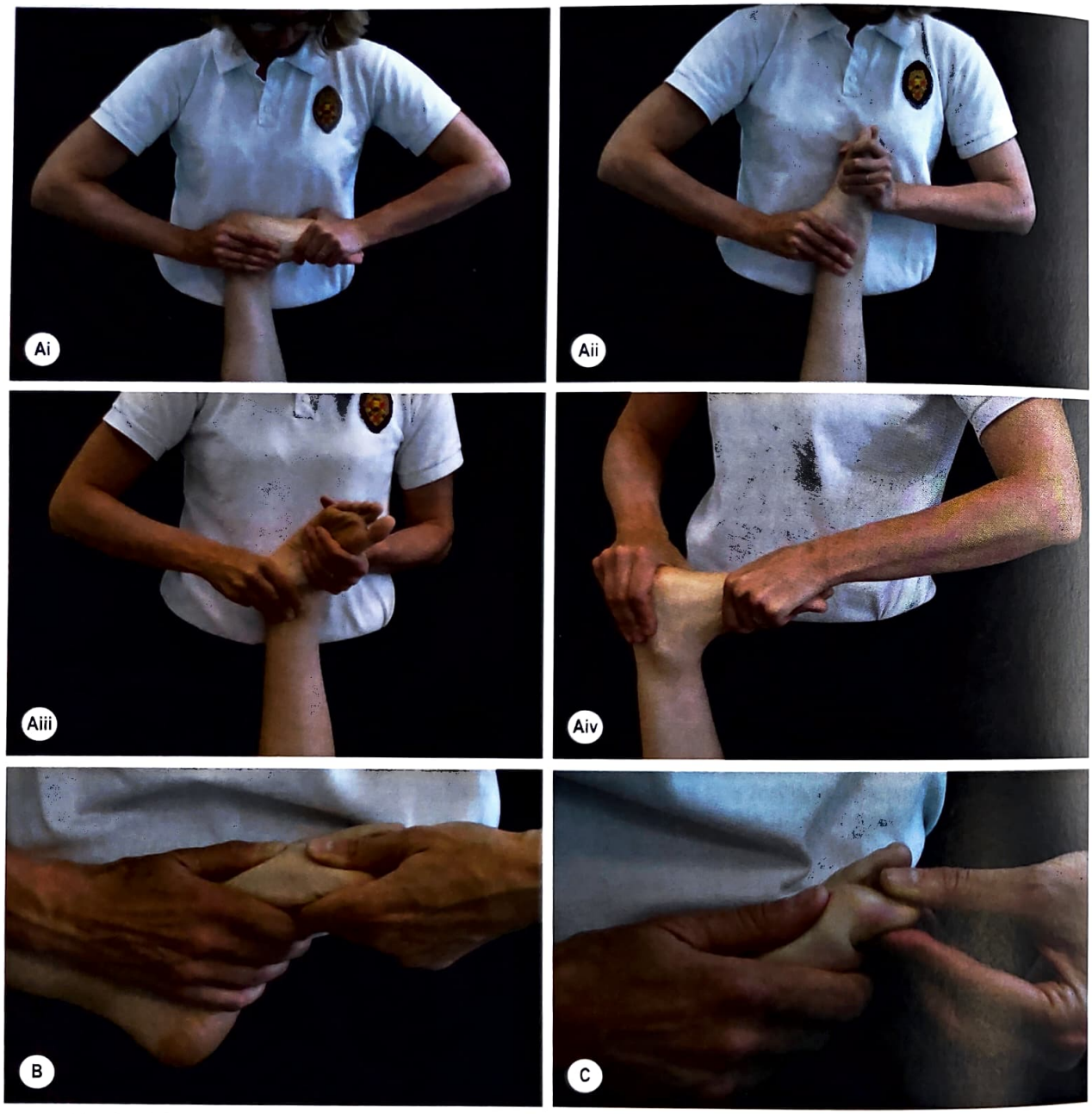


Fig. 17.2 Overpressures to the foot and ankle. (Ai) Dorsiflexion. The right hand tips the calcaneus into dorsiflexion while the left hand and forearm apply overpressure to dorsiflexion through the forefoot. (Aii) Plantarflexion. The left hand grips the forefoot, and the right hand grips the calcaneus, and together they move the foot into plantarflexion. (Aiii) Inversion. The right hand adducts the calcaneus and reinforces the plantarflexion movement while the left hand plantarflexes the hindfoot and adducts, supinates and plantarflexes the midfoot and forefoot. (Aiv) Eversion. The right hand abducts the calcaneus and reinforces the dorsiflexion while the left hand dorsiflexes the hindfoot and abducts, pronates and dorsiflexes the midfoot and forefoot. (B) Metatarsophalangeal joint flexion (demonstrated) and extension. The right hand stabilizes the metatarsal while the left hand flexes and extends the proximal phalanx. (C) Interphalangeal joint flexion and extension. The right hand stabilizes the proximal phalanx while the left hand flexes (demonstrated) and extends the distal phalanx.

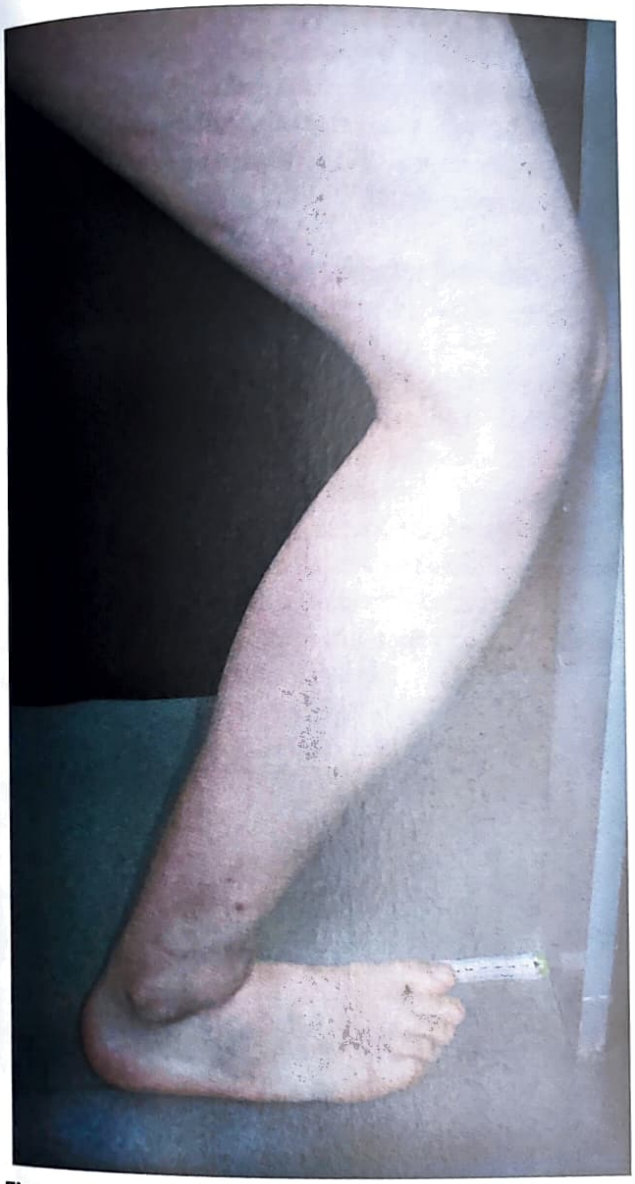


Fig. 17.3 Weight-bearing lunge test. Ankle fully dorsiflexed and knee against the wall. Note the heel is firmly on the floor and perpendicular to the wall, with measurement of the distance of the big toe from the wall.

[ATFL], calcaneofibular ligament [CFL] and posterior talofibular ligament [PTFL]), but the majority of injuries involve ATFL disruption (Martin et al., 2021). Differing mechanisms of injury are suggested for different ligamentous structures. For example, the ATFL is most likely to be injured in positions of ankle plantarflexion and inversion, whereas the CFL is vulnerable in positions of ankle dorsiflexion and inversion. Conversely, the most common position for syndesmotic injuries is ankle dorsiflexion and external

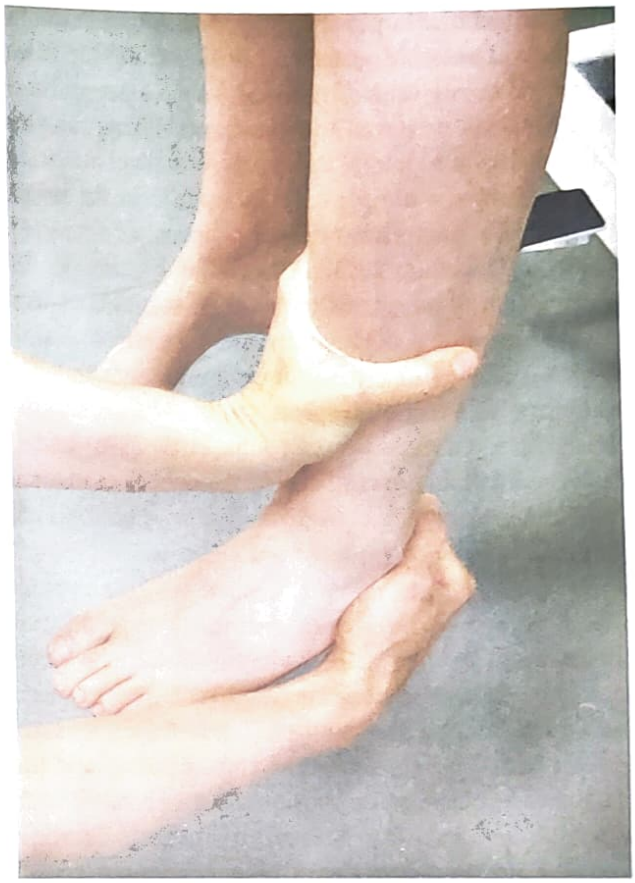


Fig. 17.4 Anterior drawer sign. The left hand stabilizes the lower leg while the right hand applies a posteroanterior force to the talus via the calcaneus.

rotation (Sman et al., 2013; Delahunt et al., 2018). For a comprehensive review of anatomical considerations see Medina McKeon & Hoch (2019). Subjective information can be combined with physical examination tests to support the clinical reasoning process. Joint integrity tests then form part of a reasoned examination.

Anterior Drawer Sign

This is a test of anterior talar translation with respect to the ankle mortise. The patient is usually positioned in sitting with 90 degrees of knee flexion and ankle plantarflexion between 10 and 20 degrees. The leg should be relaxed and unsupported. One hand of the examiner is placed on the anterior aspect of the distal tibia and fibula. The second hand grasps the posterior aspect of the calcaneus. The test is performed by applying a firm posteroanterior force to the calcaneus (and hence the talus) while the distal tibia/fibula is stabilized (Fig. 17.4). The test can also be performed in other

positions, such as supine or prone, with slight flexion of the knee. Excessive anterior translation of the talus, compared to the uninvolved side, with a loose end-feel, indicates a reduction in the passive stabilizing function of the medial and lateral ligaments (Martin et al., 2021). Observation of a dimple or sulcus sign near the region of the ATFL may also indicate a rupture of the ATFL (Cook & Hegedus, 2011; Delahunt et al., 2018). The combination of pain with palpation of the ATFL, lateral haematoma and a positive anterior drawer on examination 5 days after the injury has demonstrated a sensitivity of 96% and specificity of 84% to identify lateral ligament rupture (van Dijk et al. 1996) and is recommended in several clinical guidelines (Delahunt et al., 2018; Vuurberg et al. 2018; Martin et al., 2021) to assess ATFL integrity.

Talar Tilt

The talar tilt is a test of the amount of talar inversion occurring within the ankle mortise. The patient is usually positioned in sitting with 90 degrees of knee flexion, with the leg relaxed and unsupported and the ankle in a plantigrade position. One hand of the examiner is placed on the distal tibia and fibula while the second hand grasps the calcaneus and slowly moves it into inversion; a small amount of traction can be applied (Fig. 17.5). Increased adduction movement of the calcaneus on the involved side compared to the uninvolved side, a reduced or absent end-feel and clicks/clunks suggest injury to the lateral ligament complex or that the calcaneofibular ligament (CFL) is injured. The test can also be performed in other positions, such as supine or prone. Sensitivity ranges between 17% and 66% and specificity ranges between 82% and 100% have been reported for this test which predominantly biases the CFL (Netterström-Wedin et al. 2021; Schweitzerian et al., 2013).

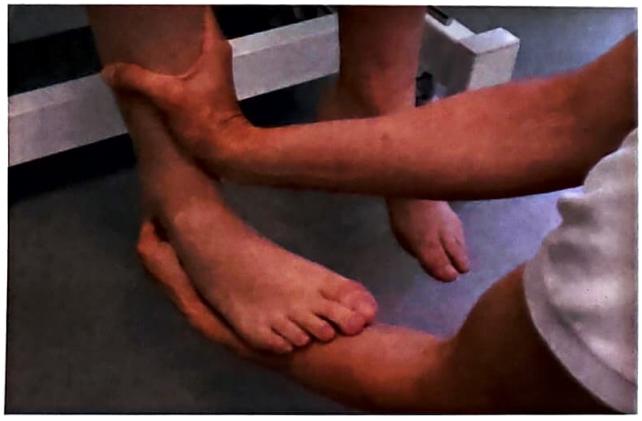


Fig. 17.5 Talar tilt. The left hand grips around the calcaneum and talus and moves it into a small amount of inversion whilst the other hand stabilizes the lower leg.

External Rotation Stress Test (Kleiger Test)

This is a test of the integrity of the inferior tibiofibular syndesmosis; it is pain provocative. The patient is usually positioned in sitting with 90 degrees of knee flexion. The examiner stabilizes the tibia and fibula with one hand in a manner which does not compress the distal tibiofibular syndesmosis. With the other hand, the examiner holds the foot in plantigrade and applies a passive lateral rotation stress to the foot and ankle (Fig. 17.6). The test can also be performed in other positions, such as supine or prone. A positive test is indicated if pain is produced over the anterior or

Fig. 17.6 External rotation stress test. The right hand stabilizes the lower leg while the left hand holds the foot in plantigrade and applies a passive external rotation stress to the foot and ankle.

posterior tibiofibular ligaments and the interosseous membrane and is indicative of a syndesmosis 'high ankle' injury. The specificity for this test has been reported at 78% with a sensitivity of 70% (Netterström-Wedin & Bleakley, 2021).

Squeeze Test

The squeeze test is a test of the integrity of the inferior tibiofibular syndesmosis; it is pain provocative. The patient is usually positioned in sitting with 90 degrees of knee flexion or in supine with the knee in a small degree of flexion. The examiner applies a manual squeeze, pushing the fibula and tibia together, and applying a force at the midpoint of the calf. The examiner then applies the same load at more distal locations moving toward the ankle (Fig. 17.7). Pain in the lower leg may indicate a syndesmotic injury (provided fracture and compartment syndrome have been ruled out). Pooled specificity data for this test was reported at 85% in a systematic review with the meta-analysis by Netterström-Wedin and Bleakley (2021), who promote the use of this test as, not/part of a cluster to include syndesmotic palpation, dorsiflexion lunge test and the external rotation stress test to help diagnose syndesmotic injuries.

Muscle Tests

Muscle system examination is based on the patient's subjective history as well as observations of posture and movement (Kendall et al. 2010). See Chapter 4 for details of muscle testing which may include isometric, isotonic and eccentric muscle testing in various parts of the range of the muscle group being tested, e.g. inner range, outer range and through range.

Muscle Strength

Manual muscle testing may be carried out for the following muscle groups:

- ankle dorsiflexors, plantarflexors
- foot inverters, evertors
- toe flexors, extensors, abductors and adductors.

For details of these tests, readers are directed to Kendall et al. (2010).

Muscle Length

The clinician tests the length of muscles that may have an impact on lower-limb function, in particular, those thought prone to shorten, that is, piriformis, iliopsoas, rectus femoris, tensor fasciae latae, hamstrings, gastrocnemius and soleus (Janda 1994, 2002). Testing the length of these muscles is described in Chapter 4.

Other Muscle Tests

Thompson's test for Achilles tendon rupture. With the patient prone and the feet over the end of the plinth or kneeling with the foot unsupported, the clinician squeezes the calf muscle; the absence of ankle plantarflexion indicates a positive test (Fig. 17.8). Sensitivity and specificity for this test to detect a subcutaneous Achilles tendon rupture have been reported as 96% and 93% respectively (Maffulli 1998; Schweitzerian et al., 2013).

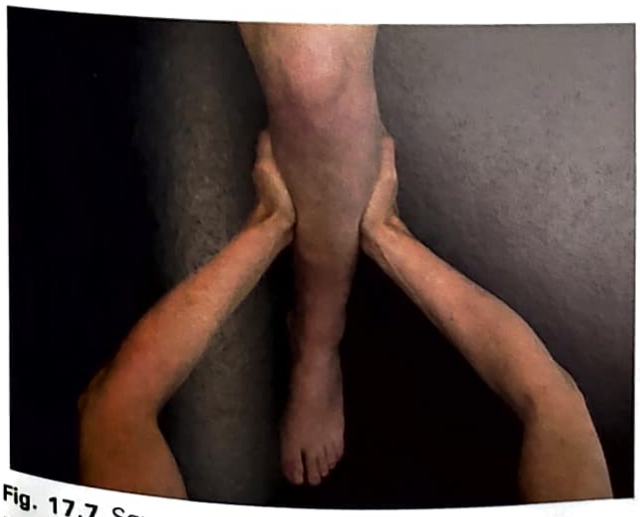


Fig. 17.7 Squeeze test. Both hands apply a manual squeeze, pushing the tibia and fibula together at the midpoint of the calf.

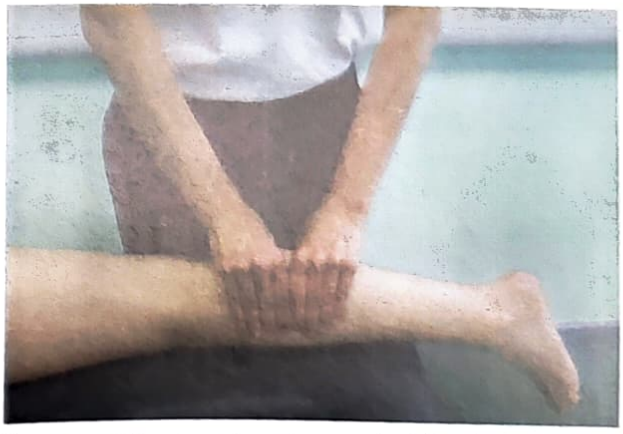


Fig. 17.8 Thompson's test. The therapist's hands squeeze the calf while observing plantarflexion movement of the foot.

Matles test for Achilles tendon rupture. The patient is positioned in prone lying and is asked to actively flex the knees to 90 degrees. The position of the ankles and feet is observed during flexion of the knee. If the foot on the affected side falls into neutral or into dorsiflexion, an Achilles tendon tear is suspected. On the uninjured side, the foot remains in slight plantarflexion when the knee is flexed to 90 degrees (Matles, 1975). Sensitivity and specificity values of 88% of 85% respectively have been reported for this test (Maffulli, 1998; Reiman et al., 2014).

Neurological Tests

The clinician will use clinical reasoning from the reported distribution and quality of symptoms, to justify a neurological examination.

Integrity of the Nervous System

Dermatomes/peripheral nerves. Sensory testing of the lower limb can be done as described in Chapter 4. Knowledge of the cutaneous distribution of spinal nerve roots (dermatomes) and peripheral nerves enables the clinician to distinguish sensory loss due to a spinal root lesion from that due to a peripheral nerve lesion. The cutaneous nerve distribution and dermatome areas are shown in Chapter 4.

Myotomes/peripheral nerves. A working knowledge of the myotomes of spinal nerve roots and peripheral nerves enables the clinician to distinguish motor loss due to a root lesion from that due to a peripheral nerve lesion. The peripheral nerve distributions are shown in Chapter 4.

Reflex testing. The following deep tendon reflexes can be tested (see Chapter 4):

- L3–L4: knee jerk
- S1: ankle jerk.

Neurodynamic Tests

Lower limb neurodynamic tests (SLR, Slump and PKB) may be used to assess for a possible neural tissue contribution to the patient's ankle and foot symptoms, see review in Chapter 4.

Variations in foot position have been suggested to stress different peripheral nerves. For example, ankle plantarflexion/inversion may bias the common peroneal nerve, ankle dorsiflexion/eversion may bias the tibial (and consequently the medial and lateral plantar nerves and the medial calcaneal nerve), whilst dorsiflexion/inversion may bias the sural nerve (Alshami et al., 2008).

Nerve Palpation

- Palpable nerves in the lower limb are as follows:
  - The tibial nerve can be palpated behind the medial malleolus, which may be more noticeable with the foot in dorsiflexion and eversion and may even produce symptoms if percussed, e.g. in tarsal tunnel syndrome (McSweeney & Cichero, 2015).
  - The common peroneal nerve can be palpated medial to the tendon of the biceps femoris and also around the head of the fibula.
  - The superficial peroneal nerve can be palpated on the dorsum of the foot along an imaginary line over the fourth metatarsal; it is more noticeable with the foot in plantarflexion and inversion.
  - The deep peroneal nerve can be palpated between the first and second metatarsals, lateral to the extensor hallucis tendon.
  - The sural nerve can be palpated on the lateral aspect of the foot behind the lateral malleolus, lateral to the Achilles.

For a review of foot and ankle entrapment neuropathies, see Pomeroy et al. (2015).

Tests for Circulation and Swelling

Vascular Tests

The vascular evaluation of the foot and ankle includes palpation of the dorsalis pedis and posterior tibial pulses and peripheral testing of capillary refill (Thordarson, 2013; King et al. 2014). The state of the vascular system can also be determined by the response of symptoms to positions of dependence and elevation of the lower limbs and response to exercise, e.g. in intermittent claudication.

Wells score for suspected deep-vein thrombosis. If an adult patient presents with signs or symptoms of deep-vein thrombosis (DVT), such as a painful warm, swollen leg, clinicians are advised to carry out an assessment of their general medical history and a physical examination to exclude other causes. National Institute for Health and Care Excellence (NICE) guidelines recommend the use of a two-level DVT Wells score to estimate the clinical probability

of DVT (NICE, 2020). From this, the patient is given a score of between −2 and +9. A simplified scoring system of two points or more indicates a likely DVT, whilst a score of one point or less indicates this is unlikely. In both situations further investigation is required; this may include a D-dimer blood test, proximal leg vein ultrasound or parenteral anticoagulant. Readers are referred to the most current NICE guidelines for further information on this topic, including details of the two-level Wells score and exceptions to these recommendations (Wells et al. 2003; NICE, 2020; NICE CKS, 2020).

Figure-of-eight ankle measurement. This test measures the size and swelling of an ankle. The patient is positioned in long sitting with both feet extended over the end of a plinth. The ankle should be in approximately 20 degrees of plantarflexion. A 6-mm (1/4-inch)-wide plastic tape measure is placed midway between the tendon of the tibialis anterior and the lateral malleolus. The tape is pulled medially toward the instep, just distal to the tuberosity of the navicular. The tape is then drawn across the arch of the foot to just proximal to the base of the fifth metatarsal, then continues across the tibialis anterior tendon, around the ankle joint just distal to the medial malleolus and then across the Achilles tendon. From here the tape circles around the ankle, ending just distal to the lateral malleolus, before returning to the start position (Fig. 17.9). The figure-of-eight method has been demonstrated to be a reliable and valid method of measuring ankle oedema (Mawdsley et al., 2000; Rohner-Spengler et al., 2007; Devoogdt et al., 2019).

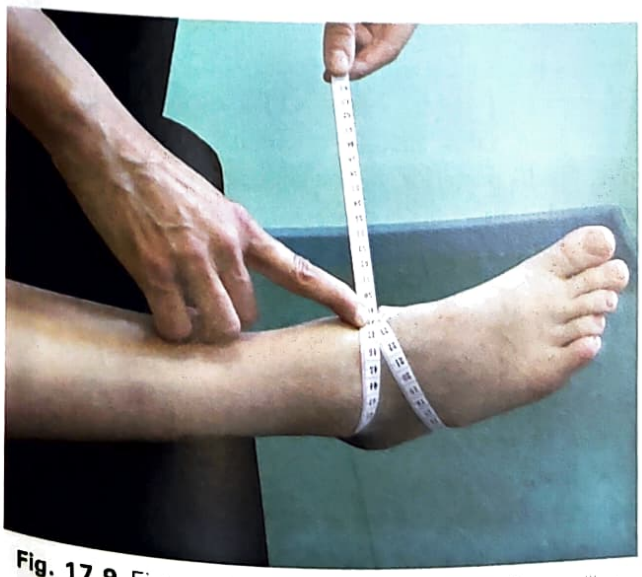


Fig. 17.9 Figure-of-eight ankle measurement for swelling.

Further Tests of the Foot and Ankle

Anterior Impingement Sign of the Talocrural Joint

This is a pain provocation test for anterior impingement of the talocrural joint (bony and/or soft tissue). The patient is usually positioned in sitting with 90 degrees of knee flexion, with the leg relaxed and unsupported. The test can also be performed with the patient supine or prone. One hand of the examiner is placed with the thumb palpating the anterolateral ankle and applying localized pressure whilst the other hand moves the ankle from a plantarflexed to dorsiflexed position (Fig. 17.10). Reproduction of symptoms signifies a positive test. Research suggests a sensitivity of 95% and a specificity of 88% for this sign (Molloy et al., 2003).

Mulder's Test for Morton's Neuroma

This is a pain provocation test for Morton's neuroma between the metatarsal heads. The patient is normally positioned in supine with the foot relaxed. This test is performed with the thumb and index finger on the plantar and dorsal aspect of the painful intermetatarsal space, exerting local pressure. The forefoot is then further compressed with the opposite hand by squeezing together the metatarsal heads. The test is considered positive if a palpable click is felt with the reproduction of pain. Mahadevan et al. (2015) report a

Fig. 17.10 Anterior impingement sign of the talocrural joint. The thumb of the right hand palpates the anterolateral aspect of the ankle joint, applying a localized pressure whilst the left hand moves the ankle from a plantarflexed to dorsiflexed position.

sensitivity of 62% and a specificity of 100% for this test compared with ultrasonography.

Star Excursion Balance Test

This is a measurement of dynamic balance of the lower limb. The Star Excursion Balance Test (SEBT) layout consists of eight lines set out from a central point, arranged at 45 degree angles (Fig. 17.11). The patient is asked to maintain balance on the lower limb to be tested while reaching as far as possible in eight different directions with the other foot, lightly touching the ground with that foot and then returning to centre. The distance achieved is measured in centimetres along each line. Patients should not move their supporting foot and keep their hands on their hips. The patient is allowed six practice and three test trials in each of the eight directions.

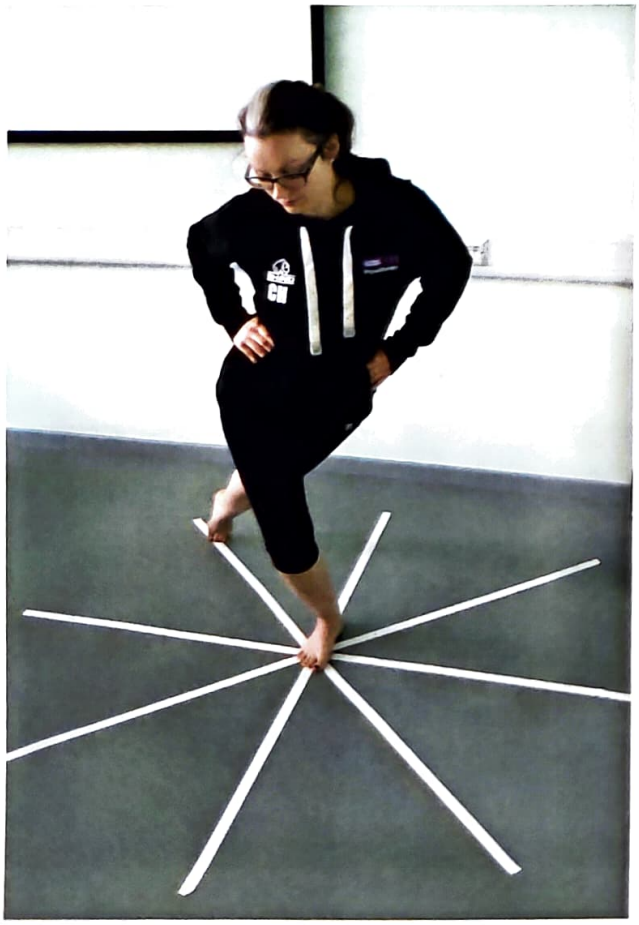


Fig. 17.11 Star excursion balance test (SEBT).

The SEBT has been shown to be a valid and reliable measure which can predict the risk of lower-extremity injury, identify dynamic balance deficits in patients with a variety of lower-extremity conditions, and is responsive to training programmes in healthy and injured populations (Gribble et al., 2012; Powden et al., 2019). Modifications to the test include a reduction of the number of practice tests to four (Robinson & Gribble, 2008) and simplifying the SEBT to three directions only (anterior, posterolateral and posteromedial); this is known as the Y-balance test (Hertel et al., 2006; Neves et al. 2017).

Palpation

Clinical reasoning will determine which structures the clinician palpates in the foot and ankle; however, it is useful to have a systematic approach to this so that nothing is missed (Alazzawi et al., 2017). Palpation findings can be recorded on a body chart (see Fig. 3.2) and/or palpation chart (see Fig. 4.34).

Suggested Approach to Systematic Palpation

Palpate bones, tendons and soft tissues for tenderness, crepitus, swelling, temperature, presence of ganglions/lumps, muscle spasm and any additional variations from the expected.

Palpate proximally to distally, starting from the proximal fibula and moving distally along the fibula to the syndesmosis, distal fibula, Achilles tendon (note if there is an intrasubstance gap which may indicate a tendon rupture), peroneal tendons laterally, PTFL, CFL, ATFL, anterior talocrural joint line, sinus tarsi, dorsalis pedis pulse, calcaneum, calcaneocuboid joint, cuboid, metatarsals, phalanges, first IP and MTP joint, first ray, tarsometatarsal joints, cuneiforms, navicular, talonavicular joint, talus, medial malleolus, posterior tibial pulse, tibialis posterior, flexor digitorum longus, flexor hallucis longus, tibialis anterior, toe extensors and flexors and the plantar fascia.

Accessory Movements

A selection of accessory movements for the foot and ankle joints are shown in Fig. 17.12 and listed in Table 17.3; however, it will not be necessary to test all of those listed, as selection will be based on clinical reasoning of findings so far in the physical examination. For example, if ankle dorsiflexion is limited then

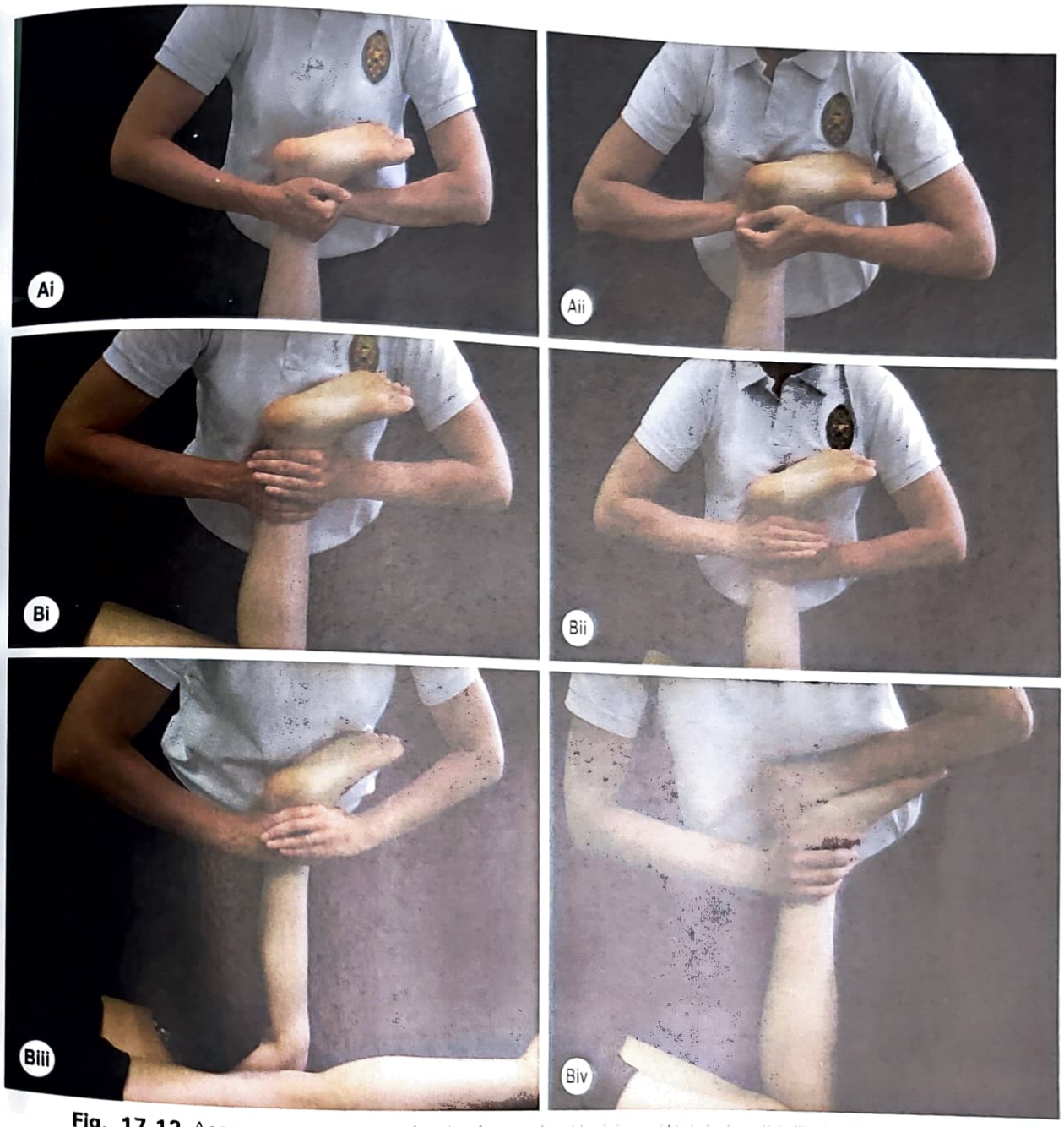


Fig. 17.12 Accessory movements for the foot and ankle joints. (A) Inferior tibiofibular joint. (Ai) Anteroposterior. The heel of the right hand applies a posteroanterior force to the tibia while the left hand applies an anteroposterior force to the fibula. (Aii) Posteroanterior. The left hand applies an anteroposterior force to the tibia while the right hand applies a posteroanterior force to the fibula. (B) Talocrural joint. (Bi) Anteroposterior. The right hand stabilizes the calf while the left hand applies an anteroposterior force to the anterior aspect of the talus. (Bii) Posteroanterior. The left hand stabilizes the tibia/fibula while the right hand applies a posteroanterior force to the posterior aspect of the talus. (Biii) Longitudinal caudad. The clinician lightly rests their leg on the posterior aspect of the patient's thigh to stabilize and then grasps around the talus to pull upwards. (Biv) Longitudinal cephalad. The right hand supports the foot in dorsiflexion while the left hand applies a longitudinal cephalad force through the calcaneus.

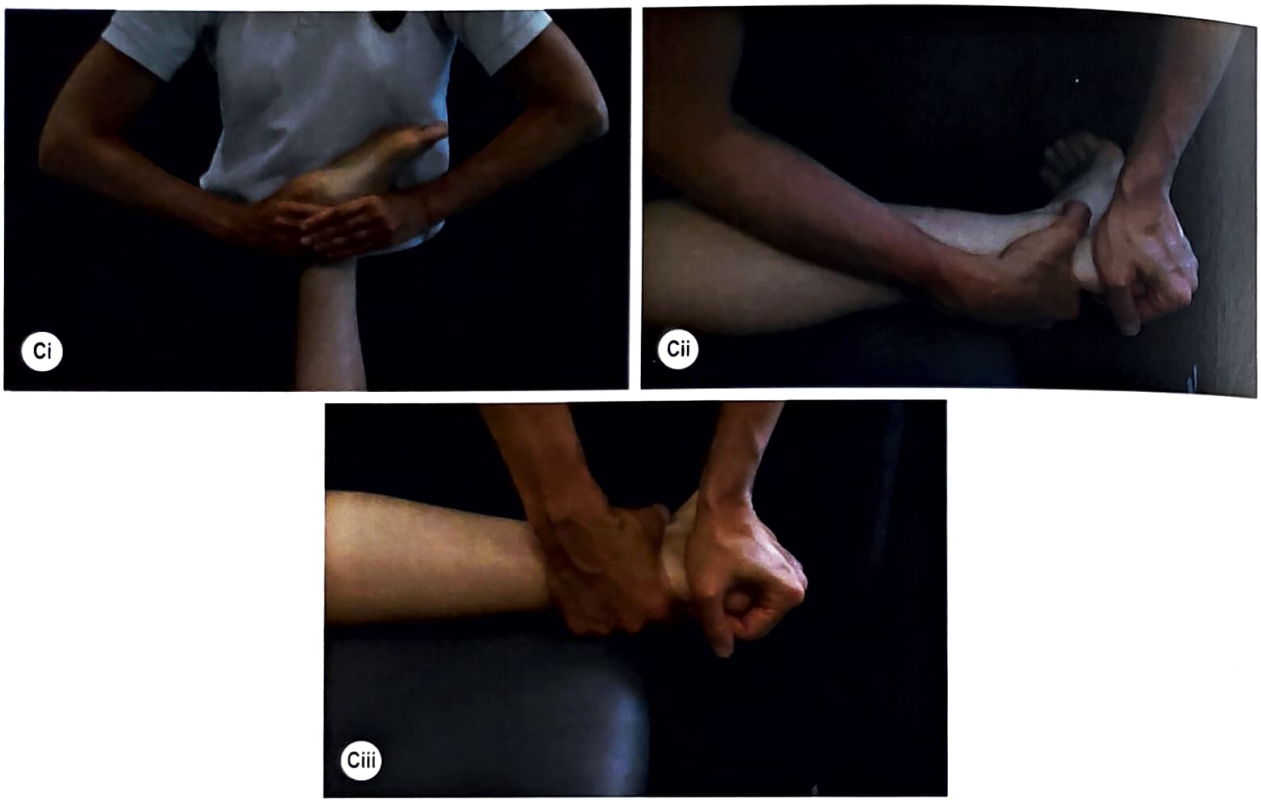


Fig. 17.12, cont'd (C) Subtalar joint. (Ci) Longitudinal caudad. The clinician lightly rests their leg on the posterior aspect of the patient's thigh to stabilize it and then grasps around the calcaneus with the right hand and the forefoot with the left hand, and pulls the foot upwards. (Cii) Transverse medial glide. The patient is in side-lying. The therapist's right hand stabilizes the talus and distal tibia with the second and third fingers in a 'V' formation, while the left hand cups around the calcaneus. The forearms are directed opposite each other, and transverse medial glide of the calcaneus relative to the talus is produced mainly via the left hand whilst the right hand maintains the position of the talus. (Ciii) Transverse lateral glide. The patient is in side-lying. The therapist's right hand stabilizes the talus and distal tibia with the second and third fingers in a 'V' formation while the left hand cups around the calcaneus. The forearms are directed opposite each other, and movement is produced mainly via the left hand whilst the right hand maintains the position of the talus.

examination may initially focus on the talocrural joint, where the majority of dorsiflexion occurs. An accessory examination can be further refined, using the Kaltenborn tests to explore joints in more detail (Kaltenborn, 2002). It is not necessary to complete all ten parts of the test. For example, if the patient's symptoms were focused around the medial aspect of the midfoot the clinician may choose to explore parts 3, 4 and 5 of the Kaltenborn test (Table 17.4).

Although joint play movement is limited, a small study comparing the judgements of two clinicians found there to be fair to good intra- and interrater reliability in identifying hyper and hypomobile joints using joint play testing test (Fraser et al., 2017).

Symptom Modification and Mobilizations With Movements

Mobilizations with movements (MWMs) are accessory movements applied during an active movement and were developed by physiotherapist Brian Mulligan (Hing et al., 2019). These techniques can be used to assess symptom modification and changes in ROM in response to MWMs; this may strengthen hypotheses relating to the structures contributing to symptoms and be considered as treatment options.

Inferior Tibiofibular Joint

The patient lies supine and is asked to actively invert the foot while the clinician applies an anteroposterior

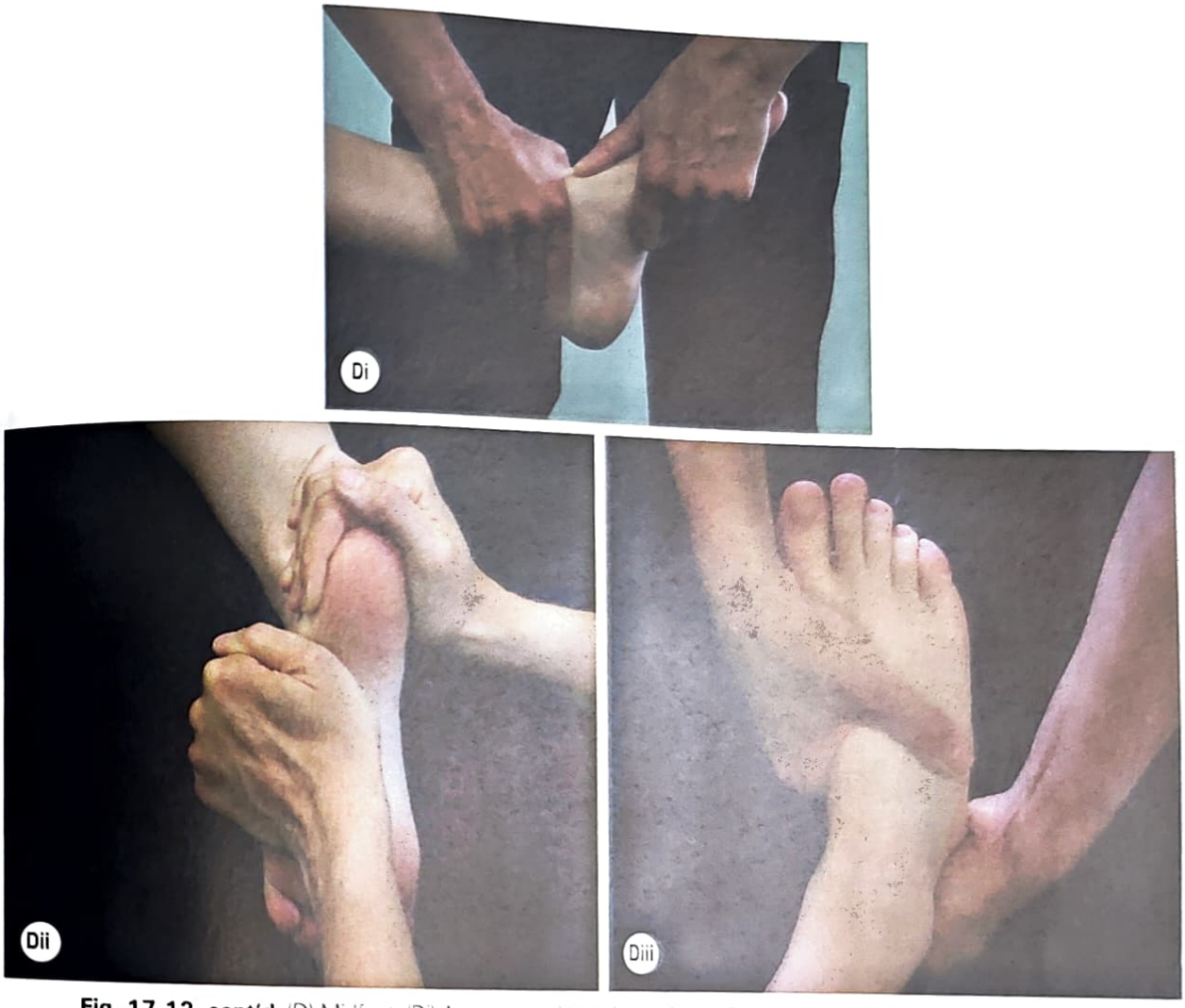


Fig. 17.12, cont'd (D) Midfoot. (Di) Anteroposterior to the navicular. Pressure is applied to the anterior aspect of the navicular through a key grip or the thenar eminence. The other hand stabilizes the talus. (Dii) Posteroanterior to the cuboid. Pressure is applied to the posterior aspect of the cuboid through the thenar eminence whilst the other hand stabilizes the calcaneum. (Diii) Abduction/adduction. The left hand grasps and stabilizes the heel while the right hand grasps the forefoot. The right hand then applies an abduction force to the foot. The foot does not evert. Hands swapped over for adduction.

glide to the fibula (Fig. 17.13). An increase in range and no/reduced pain are positive examination findings indicating a possible mechanical joint problem.

Plantarflexion of the Ankle Joint

The patient lies supine with the knee flexed and the foot over the end of the plinth. With one hand the clinician applies an anteroposterior glide to the lower end of the tibia and fibula and with the other hand rolls the talus anteriorly while the patient is asked actively to plantarflex the ankle (Fig. 17.14A). An increase in range and no/reduced pain are positive examination findings potentially indicating a possible mechanical joint problem.

Dorsiflexion of the Ankle Joint

The patient lies supine with the foot over the end of the plinth, and knee slightly flexed over a rolled towel. The clinician uses one hand to hold the calcaneus, whilst the web space of the other hand contacts the anterior talus. Both hands contribute to the anteroposterior glide of the talus, while the patient is asked to actively dorsiflex the ankle (see Fig. 17.14B). Since the extensor tendons lift the examiner's hand away from the talus,

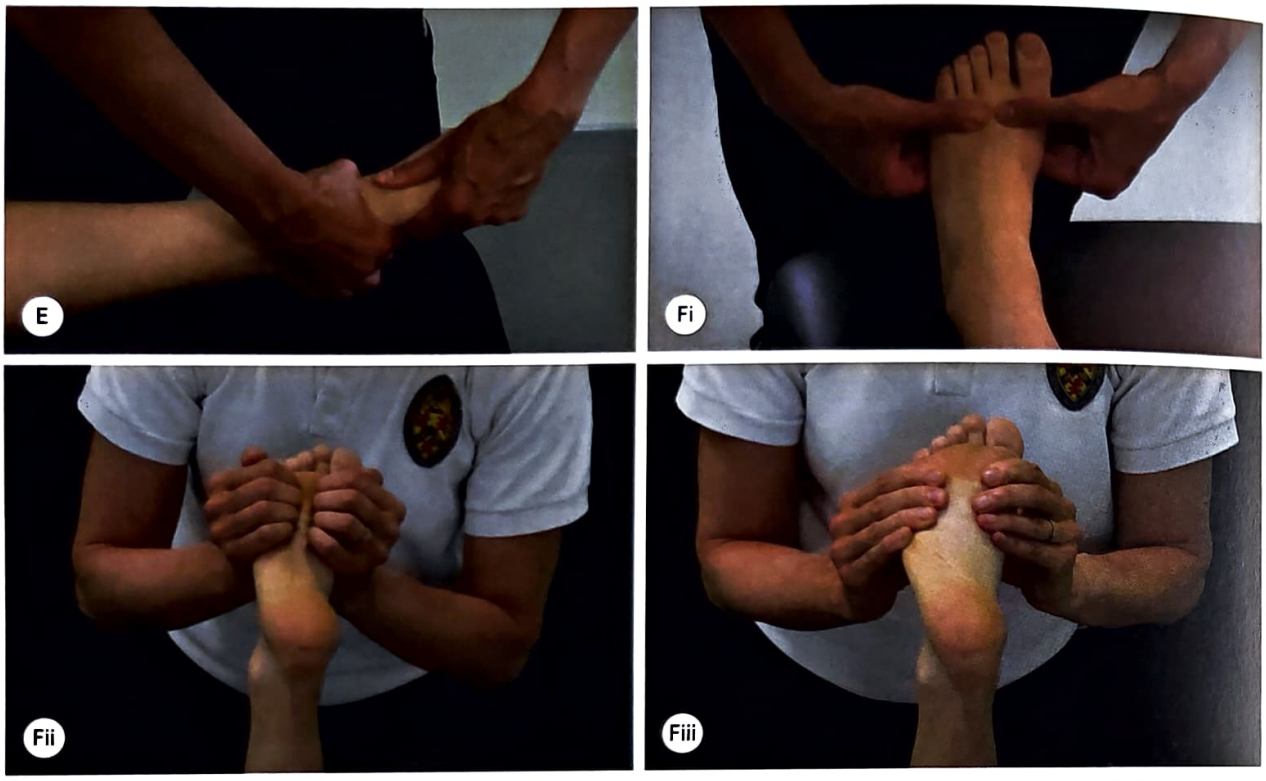


Fig. 17.12, cont'd (E) Anteroposterior and posteroanterior movement of the first tarsometatarsal joint. The right hand stabilizes the medial cuneiform while the left hand applies an anteroposterior and posteroanterior force to the base of the metatarsal. (F) Proximal and distal intermetatarsal joints. (Fi) Anteroposterior and posteroanterior movement. The hands grasp adjacent metatarsal heads and apply a force in opposite directions to produce an anteroposterior and a posteroanterior movement at the distal intermetatarsal joint. (Fii) Horizontal flexion. The fingers are placed in the centre of the foot at the level of the metatarsal heads. The metatarsal heads are then curved around the fingertips to produce horizontal flexion. You might think of folding the foot over. (Fiii) Horizontal extension. The fingers are placed in the centre of the foot at the level of the metatarsal heads. The metatarsal heads are then opened out, curving over the thumbs on the dorsum of the foot to produce horizontal extension. You might think of fanning the foot out.

the patient is asked to contract repetitively and then relax. With relaxation, the clinician moves the ankle into the further range of dorsiflexion gained during the contraction.

For further guidance on the use of mobilizations with movements, see Mulligan (2019) and Hing et al. (2019).

COMPLETION OF THE EXAMINATION

On completion of the physical examination, the clinician will need to collate the information to evaluate and revisit how findings compare with expected findings, based on the clinician's initial primary hypothesis and alternative hypotheses. Information needs to be accurately recorded. Significant findings from the subjective and physical examination can be highlighted with an asterisk* as reassessment markers for use within subsequent sessions to evaluate the effects of treatment on the patient's presentation.

It is good practice that the clinician:

- explains the findings of the physical examination and how these findings relate to the subjective assessment, offering some initial advice if appropriate.

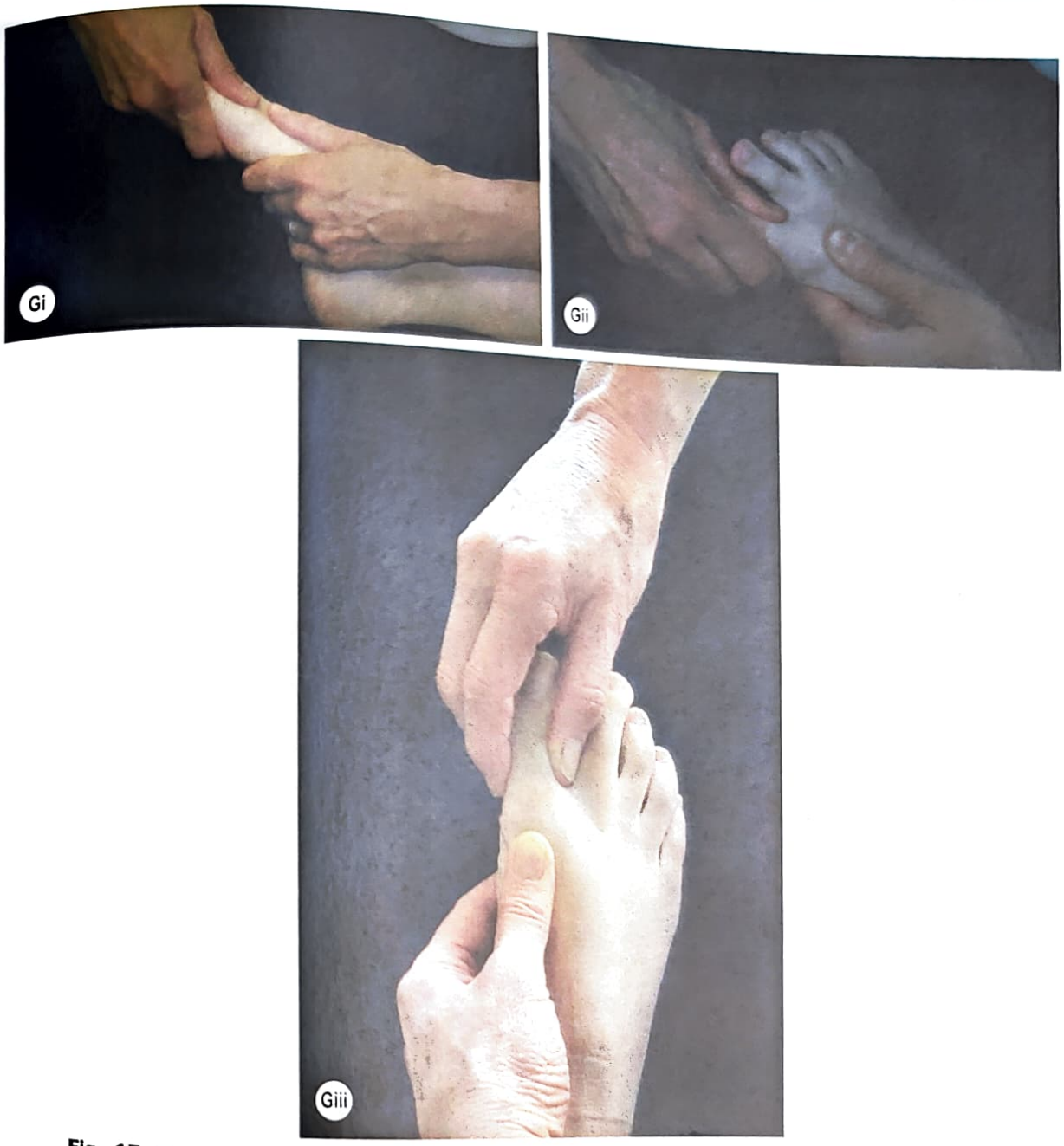


Fig. 17.12, cont'd (G) First metatarsophalangeal joint. For all these movements, one hand stabilizes the metatarsal head while the other hand moves the proximal phalanx. (Gi) Anteroposterior and posteroanterior movement. The proximal phalanx is moved anteriorly and posteriorly. (Gii) Medial and lateral transverse movement. The proximal phalanx is glided medially and laterally. (Giii) Medial and lateral rotation. The proximal phalanx is moved into medial and lateral rotation.

- allows the patient sufficient opportunity to discuss thoughts and beliefs which may well have changed over the course of the examination.
- revisits the patient's initial expectations and through collaboration with the patient identifies an agreed treatment strategy in order to achieve agreed goals.
- requests the patient to report details on the behaviour of the symptoms following examination at the next attendance.

For guidance on treatment and management principles, the reader is directed to the companion textbook (Barnard & Ryder, 2024).

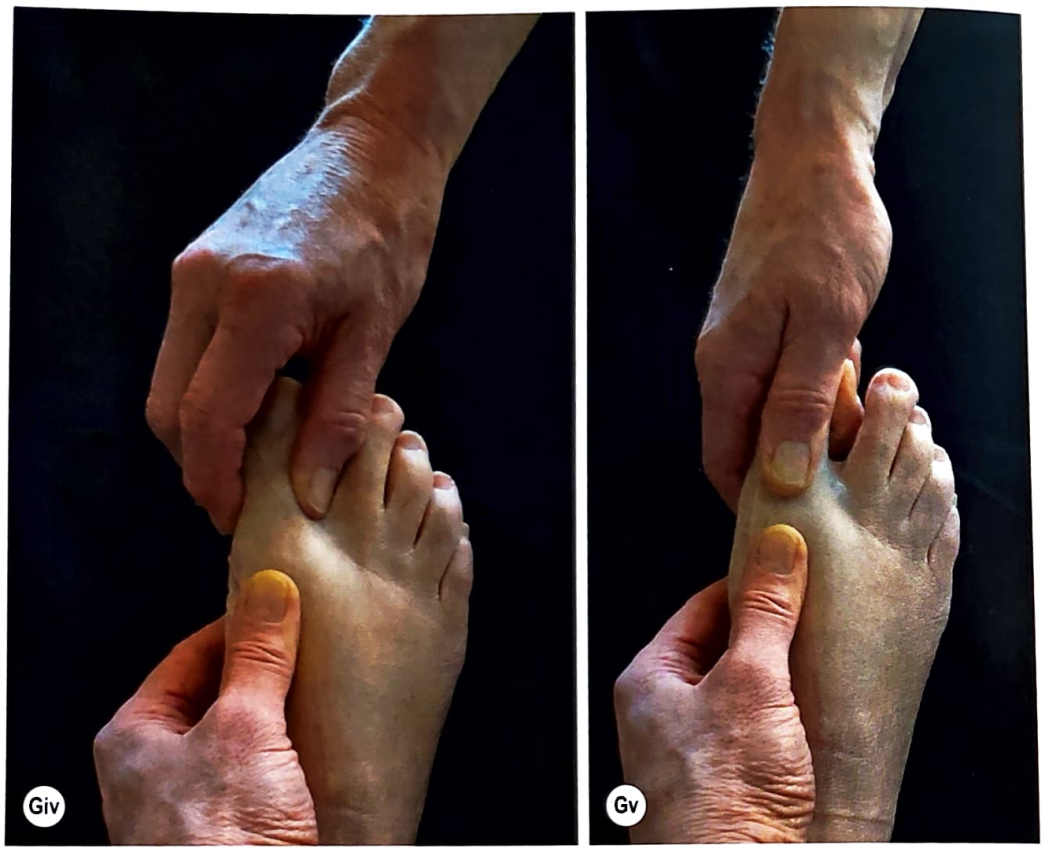


Fig. 17.12, cont'd (Giv) Abduction and adduction. The proximal phalanx is moved into abduction and adduction. (Gv) Longitudinal caudad and cephalad. The proximal phalanx is moved in a cephalad and caudad direction.

TABLE 17.3 Accessory Movements, Choice of Application and Reassessment of the Patient's Asterisks

Accessory Movements	Choice of Application	Identify Any Effect of Accessory Movements on Patient's Signs and Symptoms
Accessory Movements for the Foot and Ankle Joints	Start position, e.g.	Reassess all asterisks
Inferior tibiofibular joint	• In dorsiflexion • In plantarflexion • In inversion • In eversion	
↕ Anteroposterior		
↕ Posteroanterior		
Talocrural Joint	Speed of force application Direction of applied force Point of application of applied force	
↕ Anteroposterior		
↕ Posteroanterior		
↻ Med-Medial rotation		
↻ Lat-Lateral rotation		
↔ Caud-Longitudinal caudad		
↔ Ceph-Longitudinal cephalad		

TABLE 17.3 Accessory Movements, Choice of Application and Reassessment of the Patient's Asterisks—cont'd

Accessory Movements	Choice of Application	Identify Any Effect of Accessory Movements on Patient's Signs and Symptoms
Subtalar Joint		
Anteroposterior		
Posteroanterior		
Med-Transverse medial glide		
Lat-Transverse lateral glide		
Med-Medial rotation		
Lat-Lateral rotation		
Caud-Longitudinal caudad		
Ceph-Longitudinal cephalad		
Midtarsal Joints		
Anteroposterior		
Posteroanterior		
Med-Medial rotation		
Lat-Lateral rotation		
Abd Abduction		
Add Adduction		
Med-Medial glide		
Lat-Lateral glide		
Intertarsal Joints		
Anteroposterior		
Posteroanterior		
Med-Medial rotation		
Lat-Lateral rotation		
Abd Abduction		
Add Adduction		
Tarsometatarsal Joints		
Anteroposterior		
Posteroanterior		
Med-Medial rotation		
Lat-Lateral rotation		
Med-Medial glide		
Lat-Lateral glide		

Continued

TABLE 17.3 Accessory Movements, Choice of Application and Reassessment of the Patient's Asterisks—cont'd

Accessory Movements	Choice of Application	Identify Any Effect of Accessory Movements on Patient's Signs and Symptoms
Proximal and Distal Intermetatarsal Joints		
↕ Anteroposterior		
↕ Posteroanterior		
HF Horizontal flexion		
HE Horizontal extension		
Metatarsophalangeal and Interphalangeal Joints		
↕ Anteroposterior		
↕ Posteroanterior		
↔ Med-Medial transverse		
↔ Lat-Lateral transverse		
↻ Med-Medial rotation		
↻ Lat-Lateral rotation		
Abd Abduction		
Add Adduction		
↔ Caud-Longitudinal caudad		
↔ Ceph-Longitudinal cephalad		
?Lumbar spine	As above	Reassess all asterisks
?Sacroiliac joint	As above	Reassess all asterisks
?Hip	As above	Reassess all asterisks
?Tibiofemoral joint	As above	Reassess all asterisks
?Patellofemoral joint	As above	Reassess all asterisks

TABLE 17.4 Ten Accessory Movements of the Tarsal Bones

Movements in the Middle of the Foot

1. Fix second and third cuneiform bones and mobilize second metatarsal bone
2. Fix second and third cuneiform bones and mobilize third metatarsal bone

Movements on the Medial Side of the Foot

3. Fix first cuneiform bone and mobilize first metatarsal bone
4. Fix the navicular bone and mobilize the first, second and third cuneiform bones
5. Fix the talus and mobilize the navicular bone

Movements on the Lateral Side of the Foot

6. Fix the cuboid bone and mobilize the fourth and fifth metatarsal bones
7. Fix the navicular and third cuneiform bones and mobilize the cuboid bone
8. Fix the calcaneus and mobilize the cuboid bone

Movement Between Talus and Calcaneus

9. Fix the talus and mobilize the calcaneus

Movements in the Ankle Joint

10. Fix the tibia/fibula and move the talus or fix the talus and move the tibia/fibula

Kaltenborn (2002).

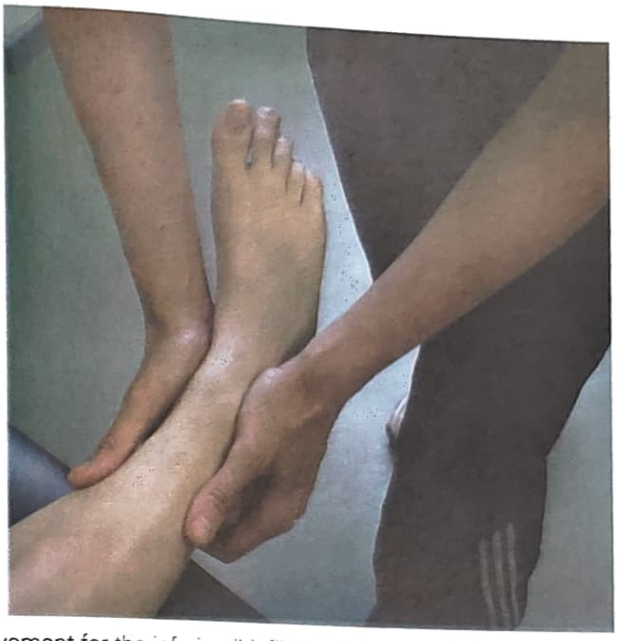


Fig. 17.13 Mobilizations with movement for the inferior tibiofibular joint. The right hand supports the ankle while the heel of the left hand applies an anteroposterior and superior glide to the fibula as the patient inverts the foot.

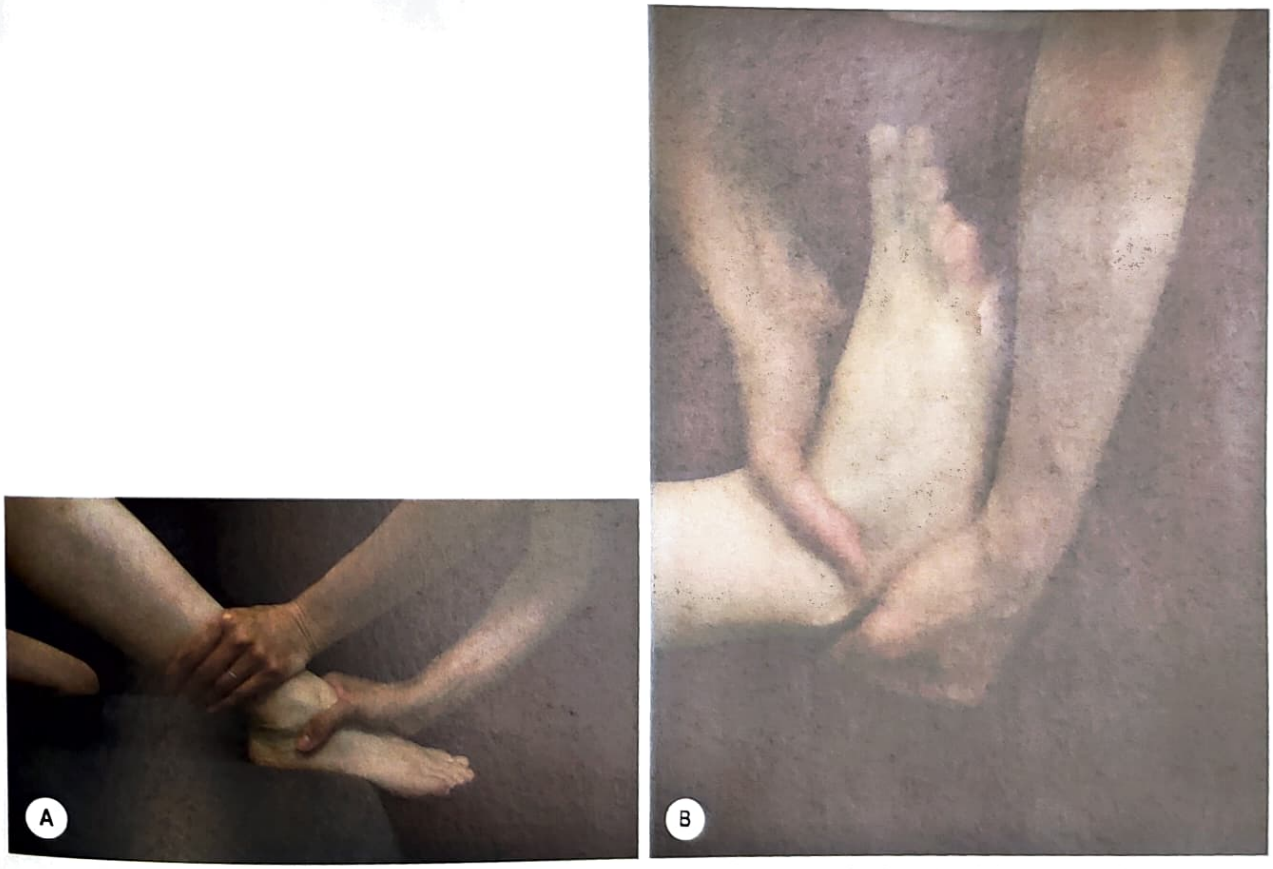
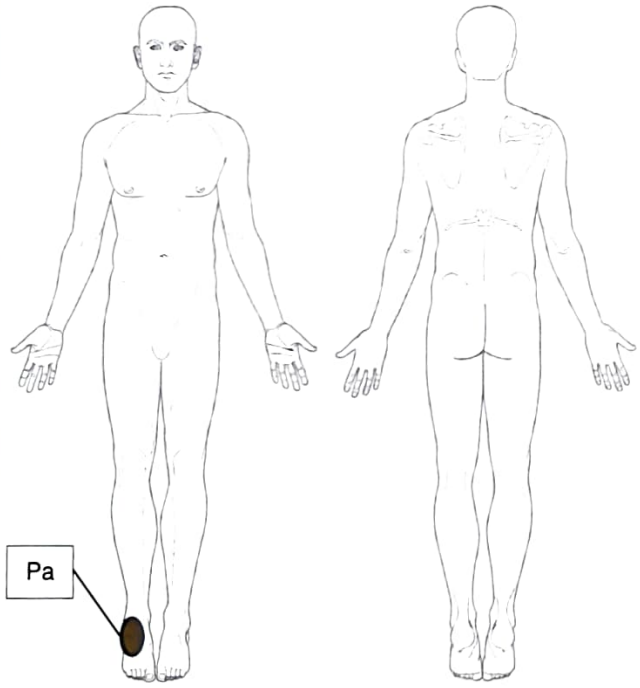


Fig. 17.14 Mobilizations with movement for the ankle joint. (A) Plantarflexion. The left hand applies an anteroposterior glide to the tibia and fibula while the other hand rolls the talus anteriorly as the patient actively plantarflexes. (B) Dorsiflexion. The left hand holds the posterior aspect of the calcaneus, and the right hand grips the anterior aspect of the talus. Both hands apply an anteroposterior glide as the patient actively dorsiflexes.

REVIEW AND REVISE QUESTIONS

1. What measurement tool is useful for the assessment of foot posture?
2. How might a patient with hallux rigidus typically present both subjectively and on physical examination?
3. 'Giving way' of the ankle is a typical symptom included in a clinical prediction rule for anterolateral ankle impingement. TRUE or FALSE?
4. Name three physical examination tests you might consider using if you suspected a patient had an acute Achilles rupture:
   a. _____
   b. _____
   c. _____
5. Which tendon is commonly associated with a pathology resulting in posteromedial pitting oedema of the ankle?
   a. Peroneus longus
   b. Tibialis posterior
   c. Achilles
6. The weight-bearing lunge test is a valid and reliable measure of ankle dorsiflexion. TRUE or FALSE?
7. How would a patient with a syndesmosis injury typically present both subjectively and on physical examination?
8. What is the name of the scoring system that aids in the diagnosis of DVTs?
9. Name one pulse you are able to palpate on the dorsal aspect of the foot and one pulse at the posteromedial aspect of the ankle.
10. Describe an evidenced-based approach to the assessment and management of an acute LAS.

Case Study



Pa—intermittent pain, generally achy but sharp with foot movements. 6/10

Aggravating factors—walking without boot, squatting activities and descending stairs; sharper pain with plantarflexing and inverting the foot. Can continue.

Easing factors—rest, settles within a few mins.

24-h pattern—activity related throughout the day. No worse first thing in the morning. Ankle swelling was better in the morning. Swelling and ankle 'ache' worsens as the day goes on if doesn't rest and elevate her leg.

Sleep—Occasionally wakes with sharp ankle pain when turning in bed at night.

No symptoms anywhere else

Subjective Examination

History of Present Condition

A 34-year-old marketing director presented to the clinic with a 6-day history of moderately severe, lateral ankle pain (VAS 6/10), swelling and haematoma affecting her right ankle, following a trauma. The pain was described as intermittent and generally achy but sharp with foot movements. She denied knee, hip or low back pain. There were no neurological symptoms.

Six days previously she had landed awkwardly when coming down the stairs and had 'rolled over' on her right ankle and heard a 'pop'. There was immediate local ankle pain and swelling, and she was unable to walk. Her husband drove her to Accident and Emergency, where she had an x-ray. She was told by medics there was no obvious fracture and was given a walking boot and elbow crutches to use. She was advised to rest as she had a 'nasty ankle sprain' and told not to drive.

Case Study—cont'd

Beliefs and Expectations

She was frightened to touch her ankle. She was concerned that she had 'ripped her ankle ligaments' and that she would not be able to return to work for a long time or to her usual gym activities, which included two classes of step aerobics per week. Her husband was supportive, but she felt she was becoming a burden as she was so restricted. She had no previous treatment or MSK problems and was trying to work from home. She hoped physiotherapy would improve her pain and help restore her normal activity levels but was concerned that she had done 'long lasting damage' to her ankle.

Aggravating and Easing Factors

The lateral ankle pain was specifically aggravated by walking without the boot, squatting activities and descending stairs; the pain also became sharper with plantarflexing and inverting the foot, e.g. when trying to put the walking boot on. She was able to continue these activities but was afraid she was doing more damage so rested frequently by elevating her leg on the sofa. After a few minutes of this, her pain settled.

24 Hour Pattern

Her ankle symptoms were activity related throughout the day and no worse first thing in the morning. The ankle swelling was better in the morning. The swelling and ankle 'ache' worsened as the day went on if she didn't rest and elevate her leg. Occasionally she woke with sharp ankle pain when turning in bed at night.

Past Medical History and Drug History

She was fit and well. She had a BMI of 23. She did not drink alcohol and had never smoked.

She took paracetamol (500 mg) irregularly up to three times a day when the ankle pain was 'really bad'.

Hypothesis After Subjective Examination

There was a clear traumatic episode which initiated the patient's symptoms. The history was suggestive of a plantarflexion and inversion mechanism of injury with associated soft tissue damage and inflammation, typical of an LAS. Local anatomical structures associated with this type of injury include the ATFL, CFL, PTFL, syndesmosis joint and ligaments, peroneals, sinus tarsi, talocrural/subtalar and calcaneocuboid joints and cutaneous nerve supply including the superficial common peroneal and sural nerve. Possible referring structures include the lumbar spine, sacroiliac joint, hip and knee joint or radicular pain emanating from a lower lumbar nerve root; however, these referred sources were unlikely given there was no previous or current history of MSK symptoms in these areas. A neuropathic cause of symptoms was unlikely given the lack of neurological symptoms. The history of ankle swelling, haematoma and a 'pop' following trauma made Achilles rupture a relevant differential diagnosis to consider.

The primary working hypothesis was that the lateral ankle ligament structures, particularly the ATFL, were the most likely source of symptoms in view of the mechanism of injury, distribution of symptoms and aggravating factors. An acute LAS (grade II or III) was thought to be the most likely pathology in view of the swelling, haematoma and exclusion of bony injury via x-ray. Being female is also a risk factor for LAS (Martin et al., 2021). Syndesmotic injury was considered less likely as symptoms were not distributed in the high ankle area and the mechanism of injury did not involve dorsiflexion or external rotation forces.

The pain mechanisms were thought to be predominantly mechanical nociception due to the intermittent nature of symptoms with clear mechanical aggravating features. In addition, there was an inflammatory component as evidenced by swelling, haematoma, symptoms easing with rest and the timeline from trauma (Watson, 2021). She displayed some catastrophization and fear-avoidant behaviours which may have impacted on her pain perception and upregulated her sympathetic nervous system. She was concerned about work, the impact of her injury on her husband and was less physically active, all of which may have reduced the resilience of her tissues and influenced her wellbeing.

The priorities for the clinical examination were to check the x-ray (in case of a missed fracture), assess the ankle joint and rule in or out LAS as a potential pathology and exclude a syndesmosis injury or missed Achilles rupture as the latter may require surgical intervention. Functional testing, measurement of swelling and ankle range of movement were to be performed, together with tests which may be clinically useful in the diagnosis of LAS; namely anterior drawer, palpation and talar tilt test (Delahunt et al., 2018; Vuurberg et al., 2018; Martin et al., 2021).

To rule out Achilles rupture the following tests were included: Thompson test, Matles test and palpation for a gap in the Achilles tendon (Boyd et al., 2015; Singh, 2017), and the squeeze test was used to assess the syndesmosis (Delahunt et al., 2018; Netterström-Wedin & Bleakley, 2021).

It was expected that there would be discomfort and possibly a reduced range of movement in all directions of

Case Study—cont'd

ankle movement but particularly into dorsiflexion, plantarflexion and inversion.

Other tests which may have proved valuable for future consideration included examination for balance function, e.g. single leg balance, SEBT, ability to jump and land and examination of gluteal strength and control (Martin et al., 2021). A review of the ankle and foot x-ray confirmed no bony injury. There were not thought to be any significant contraindications or precautions.

Physical Examination

Functional Testing

Stance, gait and one-leg control are important considerations for patients with LAS (Martin et al., 2021). Although the patient was apprehensive, she was able to stand with equal weight bearing on both feet without the walking boot on or the use of elbow crutches. She was able to mobilize without aids for short distances although had a reduced stance time and terminal stance phase due to limited dorsiflexion; there was some discomfort with walking (VAS 4/10). She was unable to single-leg stand or single-leg squat due to apprehension and discomfort in the right ankle (VAS 6/10). With double-leg squat, there was reduced dorsiflexion of the right ankle to half ROM and a valgus movement pattern at the knee.

ROM

ROM of the right knee was full and pain-free. Ankle ROM was limited to ½ for plantarflexion and inversion with movement stopped short of sharp anterolateral ankle pain. Dorsiflexion was ½ range with anterolateral ankle aching increased. The weight-bearing lunge test was limited to 2 cm on the right and 5 cm on the left.

Selective Tests

Thompson test, Matles test and palpation for a gap in the Achilles tendon were all negative. Squeeze test for, and palpation of, the syndesmosis was negative.

There was local bruising on the lateral side of the right ankle. Figure of eight measurement of swelling revealed a 30 mm difference between the left and right ankle indicating a moderate level of oedema (Rohner-Spengler et al., 2007). Local palpation of the ATFL reproduced the patient's sharp pain, but palpation of CFL did not. The talar tilt test was uncomfortable but did not reproduce the patient's specific symptoms and had a firm, stable end-feel similar to the left side. The right anterior drawer test was positive with a visible sulcus.

Accessories

As the condition was moderately severe and irritable, accessory movements were limited. There was noted increased ankle ROM and reduced pain with a mini trial of MWMs for the talocrural joint into plantarflexion in nonweight-bearing and a small increase in pain-free ankle ROM with the use of posterior-anterior talocrural mobilization. Weight-bearing MWMs were not undertaken at assessment but were planned for follow-up.

Clinical Diagnosis and Plan

Symptoms and physical signs supported the clinical diagnosis of acute LAS with probable rupture of the ATFL (Vuurberg et al., 2018). The initial plan was to explain examination findings with nonthreatening language and use a patient-centred approach to explore the patient's beliefs and expectations after the examination. Evidence-informed explanation of expected time scales for recovery was essential as was a discussion regarding the importance of completing a comprehensive exercise-based rehabilitation programme to help avoid chronic ankle dysfunction. Initial management included weaning the patient off the walking boot and elbow crutches, use of an ankle brace for up to 10 days and progressive weight bearing on the right side. The use of intermittent cryotherapy was encouraged but only in conjunction with her exercise programme. A progressive multimodal rehabilitation programme was planned to include supervised and home-based ankle and foot ROM exercises, gait re-education, neuromuscular training, coordination and balance exercises and manual therapy with encouragement to undertake a graded and scheduled return to work and sport (Vuurberg et al. 2018; Martin et al., 2021). The patient-reported FAAM outcome tool was used to evaluate treatment. If anticipated recovery was not achieved as expected, onward referral for further investigation could be considered to rule out coexisting pathologies such as osteochondral lesions, talar dome injuries, syndesmotic injuries, etc. (Polzer et al., 2012; Vuurberg et al., 2018; Martin et al., 2021). For guidance on treatment and management principles, the reader is directed to the companion textbook (Barnard & Ryder, 2024).

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