THE USE OF A CLINICAL TRIAD IN DIAGNOSING PERIPHERAL NERVE COMPRESSIONS

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BACKGROUND

In the realm of sports and athletics, the pursuit of peak performance often leads athletes to push their physical boundaries to the extreme. However, hidden beneath the ambition and dedication lies an often-overlooked adversary – the nerve compression syndromes. These conditions, marked by the mechanical, often dynamic, compression of peripheral nerves not only hinder an athlete's performance but can also cause debilitating pain and loss of muscle control and function, ultimately jeopardizing the athlete's ability to excel in their chosen sport. While electromyography (EMG) and imaging techniques have historically been primary diagnostic tools, recent revelations have illuminated their limitations in the early detection of nerve compressions.

Electrodiagnostic studies (EDS) are frequently utilized to evaluate patients suspected of upper extremity nerve entrapments, however their sensitivity and specificity, especially when diagnosing nerve entrapments beyond carpal tunnel and cubital tunnel syndromes, typically range from 30% to 65%[1, 2]. These studies are vulnerable to various pitfalls, encompassing errors stemming from technical intricacies and the operator's proficiency. Additionally, EDS may encounter challenges in discerning mixed pattern nerve injuries, possess limitations in assessing muscle function comprehensively, and frequently prove inadequate in early-stage nerve compression syndrome detection. Given these constraints, caution should be implemented in relying exclusively on EDS, advocating instead for the incorporation of clinical examination techniques.

In this article, we delve into the pivotal role that clinical examination techniques play in diagnosing nerve compressions, with a particular focus on the clinical triad of muscle, sensory, and pain testing. As we explore the multifaceted landscape of nerve compression diagnosis, we aim to underscore the significance of these clinical approaches in providing athletes with timely intervention and personalized care, transcending the constraints of traditional diagnostic methods.

The clinical triad of nerve compressions

During the early stages of nerve compression, the pressure exerted on the nerve often takes on a dynamic character, leading to disruptions in the nerve's saltatory conduction and the development of dynamic nerve ischemia. Recently, Mackinnon and her colleagues introduced a term for this particular level of nerve impairment, calling it a "Sunderland Zero"[3], denoting a dynamic nerve compression devoid of axonal loss. In cases of dynamic nerve compression, it's important to note that the compression doesn't uniformly affect the entire nerve; rather, it predominantly impacts the

superficial nerve fascicles situated at or near the compression point(s). Consequently, at specific levels in both the upper and lower limbs, such compression can result in purely sensory or motor deficits, while at other points, a combination of sensory and motor dysfunction may manifest.

To clinically ascertain the level of nerve affliction, an examination must therefore consider both motor and sensory functions, as well as recognize that most nerve compressions will result in pain at the site of compression. Based on this, a clinical triad for diagnosing upper extremity nerve compressions has been proposed[4] which includes:

1. Manual muscle testing – from proximal to distal, to delineate the level of nerve compression.
2. Sensory provocative testing – in particular the scratch-collapse test, to verify the level of nerve compression.
3. Pain testing – testing for pain (allodynia) at the site of nerve compression to additionally confirm the level of compression.

Muscle Testing Algorithm

The principles of manual muscle testing (MMT) were first described and categorized by Sir Herbert Seddon in 1954[5]. Using MMT, an examiner can proceed to diagnose weakness in isolated or sets of muscles to help delineate the level of nerve compression or affliction. The grading system has five levels, M0-M5, see Table 1.

While M0 is defined as no muscle power; M3 as full ROM and resistance against gravity; and M5 as full power against maximum resistance, the principle around the M4 level of muscle strength demands further attention.

Muscle Strength Grades

Grade	*Definition*
0	*Complete paralysis*
1	*Flicker of contraction, visible or palpable*
2	*Full ROM, without gravity*
3	*Full ROM, against gravity only*
4	*Full ROM against gravity and moderate resistance*
5	*Full ROM against gravity and powerful resistance (normal)*

Table 1: Seddon's grading of muscle strength, M0 to M5.

M4 is generally defined as the power against "some" resistance and is subdivided into three levels:

- M4-: Power against SLIGHT resistance
- M4: Power against MODERATE resistance
- M4+: STRONG power but at a submaximal resistance.

To find patients with an M4 level of weakness, the clinician must actively examine the patient for it.

Upper extremity muscle testing algorithm

In the upper extremity, a standardized algorithm for muscle testing has been developed and tested, showing good construct validity[6] and intra-rater reliability[7], as well as high sensitivity in delineating the level of nerve compression[8]. The principle is straightforward: distal to the level of nerve entrapment, distinct patterns of muscle weaknesses will be clinically present.

The algorithm of upper extremity muscle testing involves four positions[9, 10]. With the patient seated and the examiner positioned in front of the patient, the following positions (muscles) are tested.

1. SHOULDER: shoulder adduction (pectorals), shoulder abduction (posterior deltoid), and external rotation (infraspinatus) (Figure 1)
2. ELBOW: elbow flexion (biceps), and elbow extension (triceps) (Figure 2)
3. WRIST: wrist ulnar deviation (extensor carpi ulnaris), wrist extension (extensor carpi radialis), wrist flexion (flexor carpi radialis) (Figure 3)
4. HAND: extrinsic muscles (Figure 4): thumb flexion (flexor pollicis longus), index DIP flexion (flexor digitorum profundus II), little finger DIP flexion (flexor digitorum profundus V); and intrinsic muscles: thumb abduction (abductor pollicis brevis), little finger abduction (abductor digitorum minimi) (Figure 5)

Key aspects to consider in muscle testing is to:

- Start proximally and move out distally
- Do bilateral testing to compare strength
- Be consistent in testing and use POWER to work your patient
- Expect electrodiagnostic studies to be negative, as we are most often dealing with a Sunderland Zero - as coined by Susan Mackinnon and co-workers - and dynamic nerve ischemia or compression.

Strengths and limitations of MMT

The strengths of the muscle testing algorithm are that it has a proven construct validity and a high inter-rater reliability; 88 to 92% sensitivity in delineating level of nerve affliction, as shown in double-blinded studies; and accessibility - no machines or devices are needed, just the examiner and the patient.

The limitations of muscle testing include the uncooperative patient; patients with neurological disorders; and patients with bilateral problems which may limit the ability to evaluate strength.

A relative limitation is the subjectivity

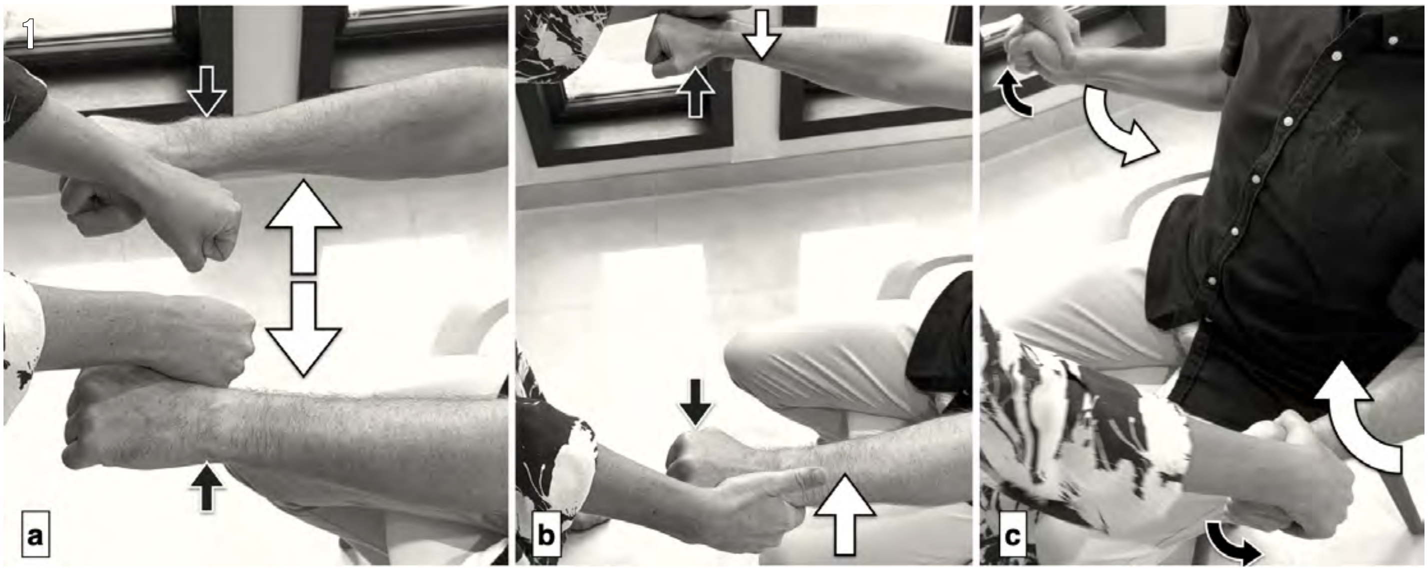

Figure 1: Muscle testing in position 1, the shoulder. a) Shoulder adduction (pectorals) is tested with the patient's arms straight. The examiner is pushing out (white arrows) and the patient pushing inward (black arrows). b) Shoulder abduction (posterior deltoid) is tested with the arm straight and shoulders abducted. The examiner is pushing on the outside of the patient's hands (white arrows), while the patient is resisting (black arrows). c) Shoulder external rotation is tested with the upper arms adducted to the body, and elbows at 90 degrees. The patient is attempting to rotate externally (black arrows) while the examiner is pushing inward (white arrows).

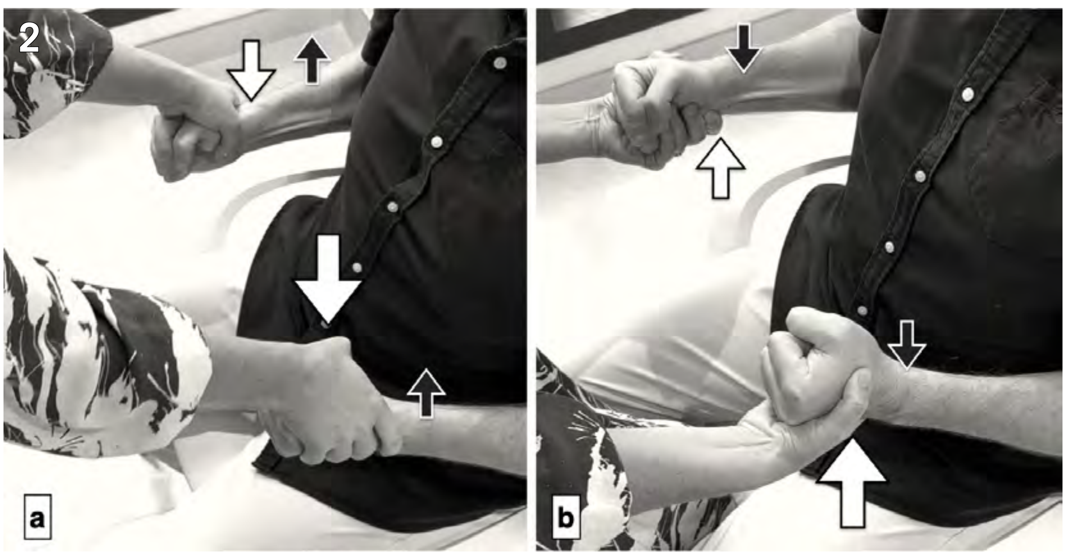

Figure 2: Muscle testing in position 2, the elbow. a) Elbow flexion (biceps): arms adducted and elbows at 90 degrees, the patient is actively flexing the elbows (black arrows) while the examiner is pushing with force downward (white arrows). b) Elbow extension (triceps): arms adducted and elbows at 90 degrees, the patient is actively extending the elbows by pushing toward the ground (black arrows) while the examiner is pushing with force upward (white arrows).

in testing, as it relies on the examiner's interpretation of findings, however, with experience and higher skill level in testing, this subjectivity is markedly low.

Lower extremity muscle testing

The lower extremity is of course also amenable to MMT, however finding M4 levels of weakness may at times be challenging as the lower limb muscles often are large and strong, limiting the ability to find a subtle loss of strength.

In cases of more distal nerve compressions, however, testing of strength in the ankle and foot can allow for clinical testing of suspected nerve compressions around the knee and ankle joints. For instance, the most common nerve compression in the lower extremity, the common peroneal nerve compression at the lateral aspect of the knee, will cause a pattern of weakness including loss of power in ankle dorsiflexion (tibialis anterior), ankle eversion (peroneus

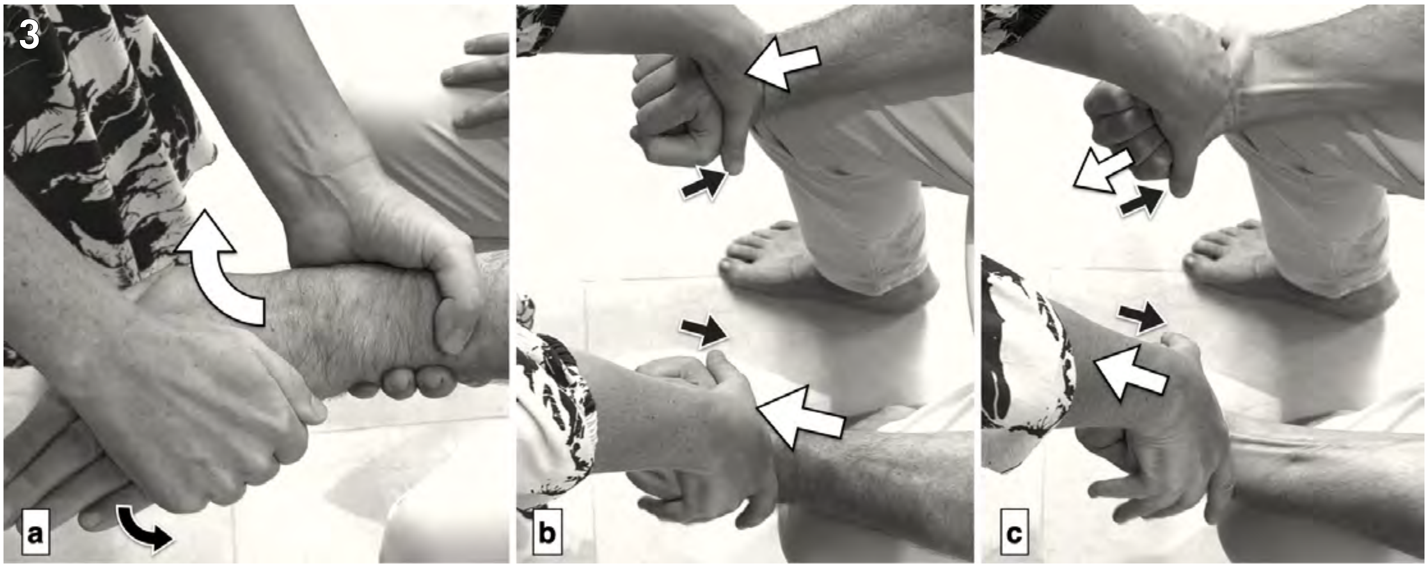

Figure 3: Muscle testing in position 3, the wrist. a) Wrist ulnar deviation (ECU): The patient's arm is fully extended, and the wrist is held in maximal ulnar deviation (black arrow). The examiner grasps the distal forearm for stability and then pushes against the ulnar border of the hand (white arrows). b) Wrist extension (ECRB): The patient rests pronated forearms against the legs and extends the wrists maximally (black arrows). The examiner pushes against the radial side of the hand (knuckles of the index and middle fingers, white arrows). c) Wrist flexion (FCR): with supinated forearms resting on the legs, the patient has maximal flexion in the wrist (black arrows), while the examiner is pushing against the radial side of the hand (white arrows).

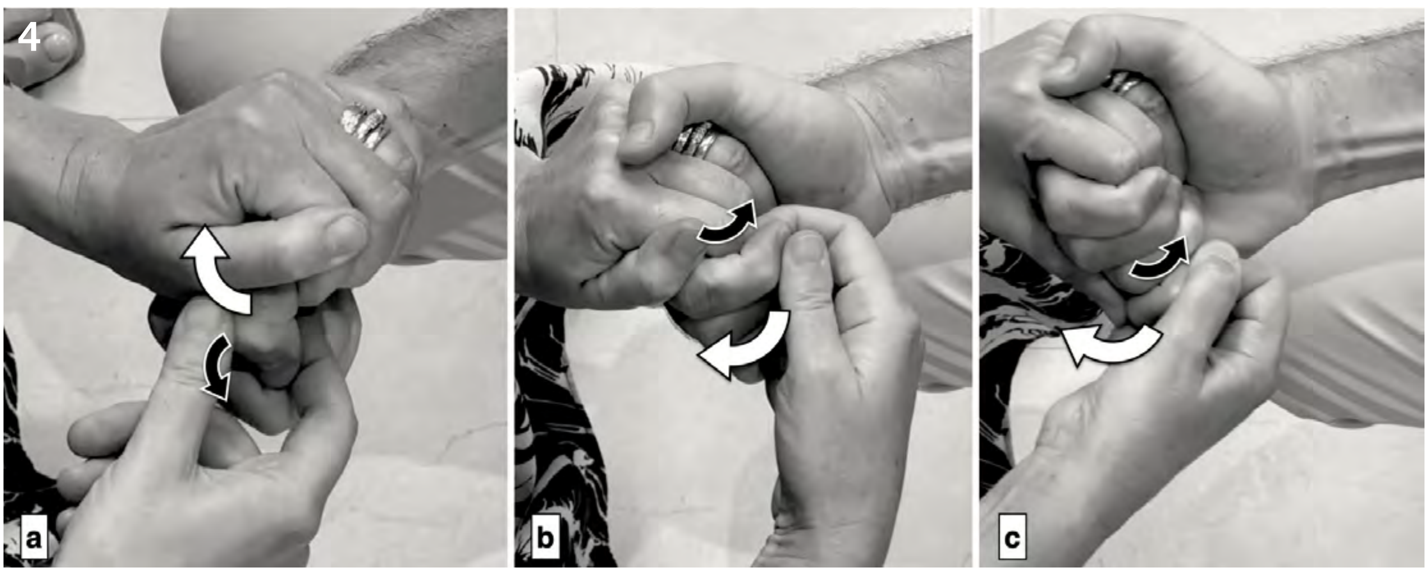

Figure 4: Muscle testing in position 4, the hand extrinsics. a) Thumb flexion (FPL): The examiner isolates the thumb interphalangeal (IP) joint by holding one hand around the proximal phalanx. The patient flexes the IP joint maximally (black arrows) while the examiner tries to move the distal phalanx upward (white arrows). b+c) Index and little finger flexion (FDP2, FDP5): With the wrist in slight flexion, the distal interphalangeal (DIP) joint of the index and little finger, respectively, are isolated and flexed maximally (black arrows) while the examiner attempts to extend the joints (white arrows).

Figure 5: Muscle testing in position 4, the hand intrinsics. a) Thumb abduction (APB): With the forearm in supination, and the hand flat, the patient lifts the thumb toward the ceiling (black arrows) while the examiner pushes in a downward motion (white arrows). b) Thumb abduction (ADM): Forearm still in supination, the patient does a maximal abduction of the thumb (black arrows). The examiner proceeds by pushing on the outside of the little fingertip (white arrows).

longus), and big toe extension (extensor hallucis longus)[11].

The Scratch-Collapse Test

The scratch collapse test (SCT) was first described by Cheng, Beck, and Mackinnon in 2008[12], and has since been used in several publications to clinically verify levels of nerve entrapment in the upper and lower extremities[4,13-15]. In carpal tunnel and cubital tunnel syndromes, the SCT has a diagnostic accuracy of 82 and 89%, respectively, rendering this test more sensitive than the commonly used Tinel's and flexion nerve compression tests[12]. A recent systematic review has shown that the pooled knowledge of the SCT renders it a test with a high level of specificity but controversy regarding the sensitivity. This means that the test itself is not a stand-alone test, but one to use in conjunction with others. The use of SCT is thus to aid the clinical diagnosis of nerve entrapment, where manual muscle testing is used to delineate the level of nerve entrapment and SCT is used to verify this level of entrapment.

Technique

The concept of SCT is that a patient with a focal nerve entrapment has an area of skin allodynia located at the level of nerve entrapment. When scratching this area of skin, a brief spinal reflex causes a momentary loss of voluntary muscle contraction.

Clinically, the patient is seated with elbows flexed to 90°, shoulders adducted and slightly externally rotated. The patient is asked to resist bilateral internal pressure applied by the examiner onto the forearms. The area of suspected nerve entrapment is then gently scratched, and pressure again applied onto the forearms. In the event of a focal nerve compression, the patient will feel a distinct loss of muscle strength in the affected arm[12,13] (Figure 6).

Cold-spray test

Topical ethyl chloride (cold-spray) may be used to further verify the site of nerve compression. The examiner will perform the SCT as described above. When the test is positive, the examiner may proceed to apply cold-spray over the skin where the SCT is tested and then repeat the test. If the nerve compression level is correct, the cold spray will render the SCT negative – meaning that the patient will remain strong[16].

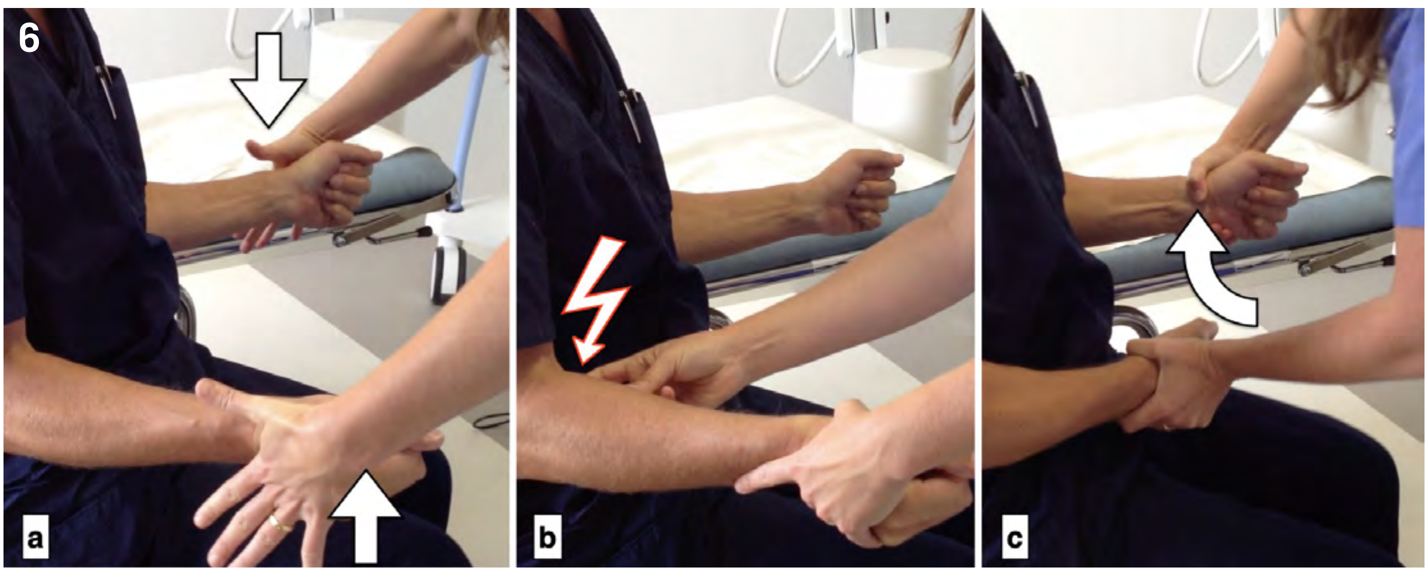

Figure 6: Performing the scratch collapse test. The patient is seated with elbows flexed to 90°, shoulders adducted, and slightly externally rotated. The patient is asked to resist bilateral internal pressure applied by the examiner onto the forearms (white arrows). The area of suspected nerve entrapment is then gently scratched (flash symbol), and pressure is again applied to the forearms. In the event of a focal nerve compression, the patient will feel a distinct loss of muscle strength in the affected arm (curved arrow).

> *It is crucial to recognize the potential impact of nerve compression syndromes on an athlete's performance and health.*

Common Findings

When using a structured method to examine a painful upper or lower limb in an athlete, clinicians may often discover additional compression points beyond their initial expectations. While it's crucial to rule out other potential joint issues like ligament sprains, cartilage injuries, or chronic exertional compartment syndrome, it's equally important to consider the possibility of nerve compression syndromes when evaluating athletes with persistent subacute or chronic pain and limb issues, especially in situations where there's no clear history of trauma.

Some of the most common nerve compressions encountered include:

- *Proximal median nerve compression*, a.k.a lacertus syndrome. Frequently seen in throwing and racket/batting sports and often misdiagnosed as medial epicondylitis. Clinical findings include weakness in FCR, FPL, FDP II; positive SCT over the lacertus fibrosus and pain where the median nerve runs underneath the lacertus.
- *Radial tunnel syndrome*. Often seen in conjunction with, or misdiagnosed as, lateral epicondylitis or "tennis elbow". Clinical triad shows weakness in ECU, positive SCT over the arcade of Frohse, and pain where the posterior interosseous nerve enters the arcade of Frohse (under the proximal supinator edge).
- *Suprascapular nerve compression*. Encountered in overhead throwing athletes, i.e., volleyball players and pitchers. Results in a weakness in the infraspinatus muscle (shoulder external rotation), with positive SCT over the suprascapular notch and pain in the same area.
- *Common peroneal nerve compression*. Seen in athletes with lateral knee pain, especially in cases of chronic pain, and sometimes following other knee surgery. Clinical findings include pain over the fibular head, weakness in the ankle, and big toe dorsiflexion, as well as positive SCT over the peroneal nerve just distal to the fibular head.

CONCLUSION

Athletes are no strangers to pushing through discomfort, often persevering in their training despite experiencing pain. However, when an athlete reaches a point where pain significantly hinders their ability to perform in their sport, or when they contend with persistent muscle control issues and fatigue during or after training sessions, seeking medical advice becomes imperative. For healthcare professionals entrusted with the care of athletes, including team physicians, physiotherapists, and surgeons, it is crucial to recognize the potential impact of nerve compression syndromes on both an athlete's performance and overall health.

To effectively address these concerns, a systematic approach is essential. The clinical triad, encompassing muscle testing, the scratch collapse test, and pain assessment, offers a structured and straightforward method for screening potential nerve compression disorders as contributing factors to an athlete's difficulties. It is noteworthy that even when electrodiagnostic studies and imaging, including MRI scans, yield normal results, a thorough evaluation of nerve compression syndromes can offer valuable insights into an athlete's condition.

Abbreviations

ADM	abductor digiti minimi
APB	abductor pollicis brevis
DIP	distal interphalangeal joint
ECU	extensor carpi ulnaris
EDS	electrodiagnostic studies
EMG	electromyography
FCR	flexor carpi radialis
FDP2	flexor digitorum profundus index finger
FDP5	flexor digitorum profundus little finger
FPL	flexor pollicis longus
IP	interphalangeal joint
SCT	scratch collapse test

References
Available at www.aspetar.com/journal

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