

# CLINICAL NEURODYNAMICS IN SPORTS INJURIES

## ORIGINS AND NEW DEVELOPMENTS

– Written by Michael Shacklock, Australia

### INTRODUCTION

Physical tests for involvement of neural structures in musculoskeletal disorders have been in existence for quite some time now, the first known one being introduced in 2800 BC by the Egyptian physician Imhotep as he described a 'leg straightening manoeuvre' in physical examination of people with back pain. Since then, much discussion about the test has occurred, following various prominent authors such as Lasègue in 1864 and Forst in 1881<sup>1</sup>, Charnley<sup>2</sup>, von Lanz and Wachsmuth<sup>3</sup> and Breig<sup>4</sup>.

From data obtained at surgery in patients with sciatica, Charnley<sup>2</sup> described the abnormal straight leg raise test as a reflection of intervertebral disc protruding onto the local nerve root. More contemporary studies support this concept that such compression also compromises

intra-radicular blood flow, the capacity of the nerve root to slide in the intervertebral foramen<sup>5</sup> and nerve root conduction<sup>6</sup>. Since these manoeuvres emerged, our understanding of the integrative actions between the nervous and musculoskeletal systems has continued to grow rapidly and provide new and complex insights into the management of musculoskeletal and sports injuries.

Even so, we physiotherapists initially examined simplistically with respect to the idea that such physical tests were a reflection of solely the 'length' or 'flexibility' of nerves which were often interpreted to be 'tight'. Clinically, we therefore sought to increase their length and mobility through 'nerve stretching' or 'mobilising' techniques<sup>7</sup>. At that time, it was not realised that such marked increases in tension produced by the stretches or mobilisations were likely to

be harmful, nor did we fully appreciate the complex nature of the local effects on the nerves and the musculoskeletal structures which are closely interwoven.

A significant extrapolation of the above marked the advent of the straight leg raise test of the upper limb, originally documented by Von Lanz and Wachsmuth<sup>3</sup> and developed into a much more useable clinical test by Elvey<sup>8</sup>. In the interim, the test has had different names such as 'brachial plexus tension test', 'upper limb tension test' and 'upper limb neurodynamic test'. Subsequently there became cause to re-examine these tests which took us from the initial idea of 'nerve tension' toward a new understanding of more factors that contribute to the health of the nerve and its related surrounding structures, as well as those it innervates<sup>9-11,21</sup>. Such aspects consist of how the nervous system moves and



**Figure 1:** Standard median neurodynamic test to end range with structural differentiation (Reproduced with permission from Elsevier, Oxford<sup>21</sup>).

**Figure 2:** Standard slump testing for low back pain and sciatica (Reproduced with permission from Elsevier, Oxford<sup>21</sup>).

**Figure 3:** a) Neurodynamic test of the radial sensory nerve. b) Neurodynamic test for the peroneal nerve (Reproduced with permission from Elsevier, Oxford<sup>21</sup>).

interacts with the musculoskeletal system and the relevant physiological changes that can interact between the two<sup>10,11</sup>.

Finally, optimum human performance and movement are essential for sporting success, such that these aspects are deeply involved in sports medicine and physiotherapy and movement science. However, one of the impediments to such success to emerge in this area is the potential for a neural component to sports injuries (e.g. sciatic nerve component to hamstring injury). A key aspect of management and treatment of the athlete and sportsperson is detailed diagnosis and treatment. This brief review aims to outline the status of the science regarding the examination of the nervous system in musculoskeletal

conditions and describes current thoughts regarding the diagnostic and therapeutic implications of research in this area.

#### *Origins and basis of the 'neurodynamics concept'*

Mechanical treatment of neural tissues in physiotherapy have been in existence for quite some time now<sup>7,8,12-14</sup>. In the early stages of the neural approaches, many of the techniques were based on only a small number of mechanisms and many aspects of a potentially new approach were missing. Those early approaches had other names, for instance adverse neural tension and neural mobilisation, in which a key part was stretching and moving nerves. However, since then the approach has

developed considerably and is now reflected in a more expansive and multi-mechanism approach<sup>9,11</sup>.

During the development of the neural approaches there arose a set of standard physical tests. These were directed at the upper limb, spine and lower limb and consist of the median (upper limb) neurodynamic test (Figure 1), slump test (Figure 2) and straight leg raise tests respectively. A further development was that these tests were given variations in which they could be sensitised with more extensive or specific movements. In addition, even specific joint movements are now used to test and treat specific peripheral nerves, for instance the radial sensory, peroneal, tibial, sural, obturator and femoral. Now there is a



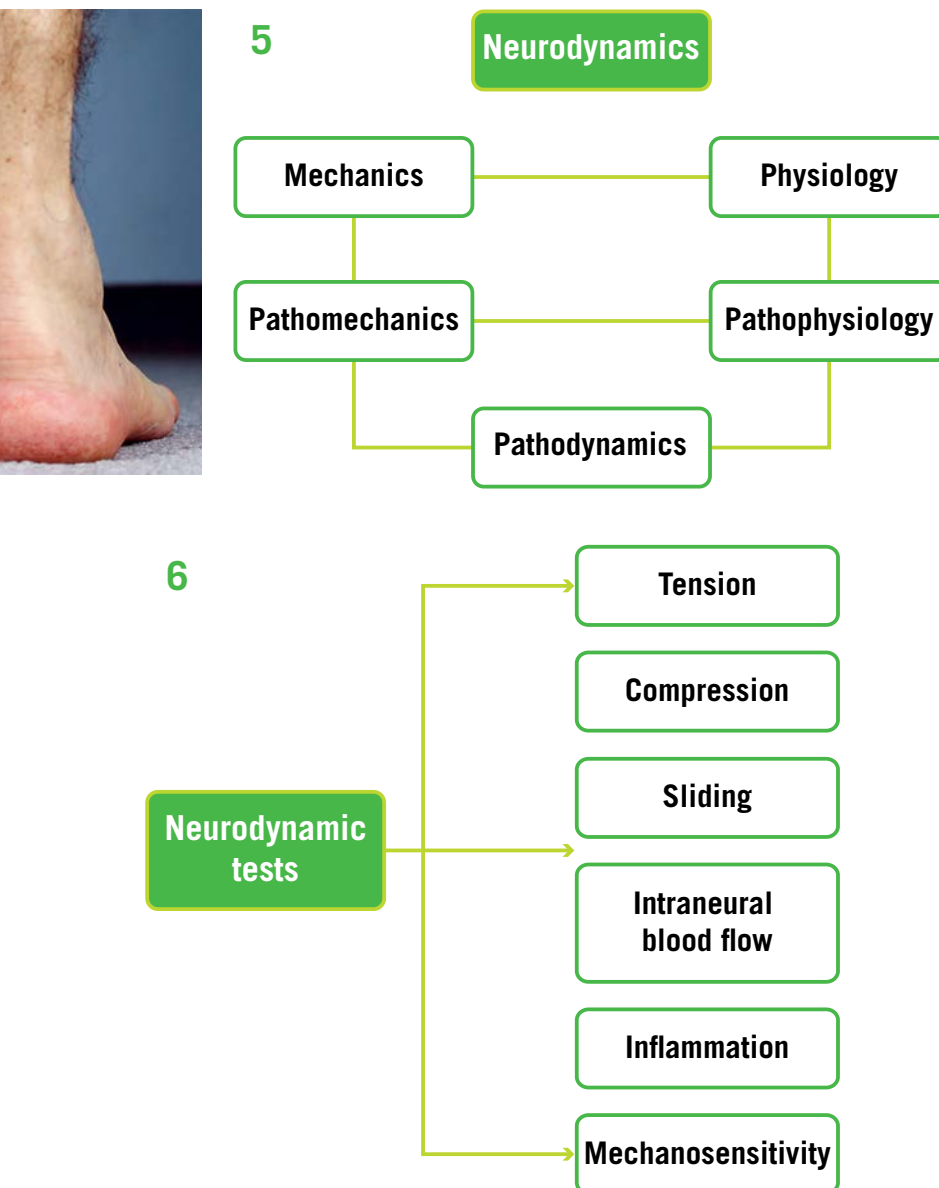
neurodynamic test and treatment available for virtually all the major nerves of the body (Figure 3a and b).

#### KEY MECHANISMS AND CORNERSTONES

##### *Interdependence of mechanics and physiology of the nervous system*

The concept of neurodynamics relies on several key proposals, one of which is the fact that, in our patients, mechanics and physiology of the nervous system are often dynamically interdependent. Changes in pressure and tension in the nervous system produce changes in blood flow<sup>5,15,16</sup>, inflammation and mechanosensitivity in the neural tissues<sup>17-19</sup> which can have important clinical consequences. For instance, if a sportsperson pronates excessively at the ankle, this movement tightens and compresses the tibial nerve at the tarsal tunnel<sup>20</sup> and may produce foot or heel pain from a local tibial nerve component (Figure 4).

Likewise, changes in physiology of the nervous system may also produce changes in mechanical function. Diabetic neuropathy is a good example whereby the axons in a peripheral nerve may become swollen, endoneurial fluid pressure increases, scar tissue may develop and the nerve's mechanical function is compromised. Given a normal or optimal mechanical environment for the nervous system, the system has a good opportunity to remain normal and be free of symptoms. However, in the event that pathomechanics develop, a cascade of pathophysiological events can occur in the neural tissues, such as those mentioned above. Each of those pathophysiological facets are key issues for the patient and



**Figure 4:** Pronation of the hindfoot producing increased tension and pressure in the tibial nerve as it passes through the tarsal tunnel.

**Figure 5:** Concept of neurodynamics linking mechanics and physiology of the nervous system (Reproduced with permission from *Physiotherapy*<sup>10</sup>).

**Figure 6:** Local mechanisms involved in neurodynamic test (Reproduced with permission from Elsevier, Oxford<sup>21</sup>).

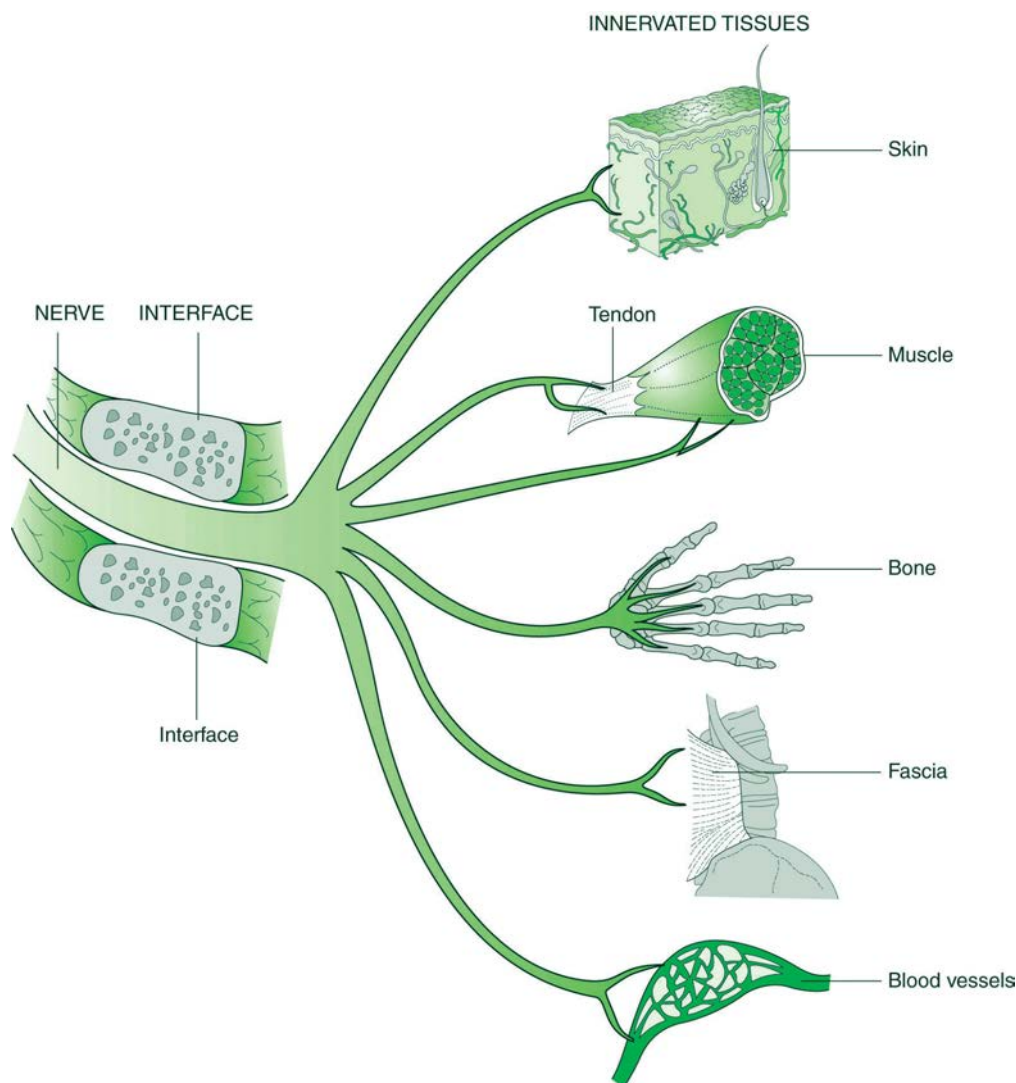
can be treated with mechanical techniques which makes neurodynamics ideal for the physiotherapist to apply clinically (Figure 5). In the event that an abnormality in neural function exists, both pathomechanical and pathophysiological aspects may be involved. In any case, mechanical treatment is performed as a means of improving both aspects.

Conceptually, one of the most important aspects of mechanical testing of the nervous system is the idea that we should be calling the tests and movements a name that

reflects the exact relevant mechanisms: mechanics (tension, sliding pressure) and physiology (intraneural blood flow, sensitivity and inflammation) in the patient. This is why the term 'neurodynamic test' is recommended<sup>10,21</sup> (Figure 6).

##### *Integrative functions of the nervous and musculoskeletal systems*

The musculoskeletal system is effectively the container, and forms a mechanical interface for the nervous system. It is paramount that the nervous system be



**Figure 7:** Layout of the neurodynamics system, interface, neural and innervated tissues (Reproduced with permission from Elsevier, Oxford<sup>21</sup>).

placed in as healthy an environment as possible in order for it to function optimally. When the mechanical interface misbehaves in the form of mechanical dysfunction, its relationship with the nervous system becomes compromised and function of the nervous system may become abnormal. Hence, a key aspect of the neurodynamics approach is that diagnosis and treatment of the musculoskeletal and nervous systems are integrated.

Another important aspect is that, from structure and function perspective, the system comprises three parts:

1. mechanical interface,
2. neural and
3. innervated tissues.

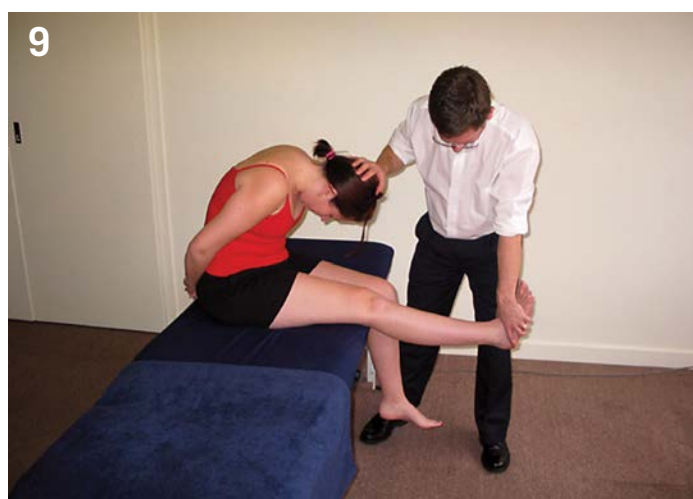
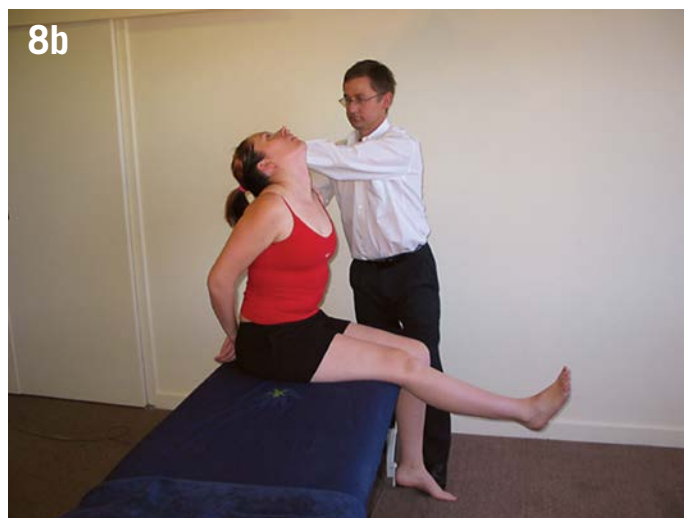
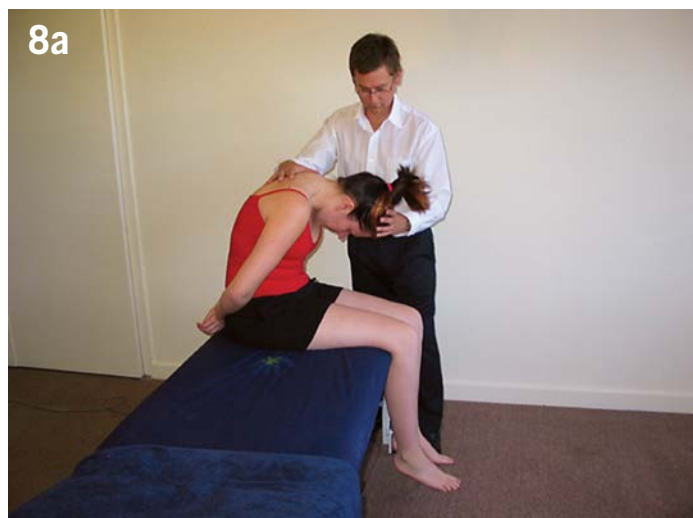
This layout provides the clinician with a number of important opportunities: to understand how to move the nervous system specifically and how to formulate diagnostic categories in relation to abnormal neurodynamics (Figure 7).

For instance, a sportsperson might have a repetitive movement to perform during training or sport. If this activity produces excessive compression of nerves by the interface, then it may be necessary to offer movement-based protective strategies in relation to the affected neural structure. This could naturally apply to nerve root or local peripheral nerve and would be categorised as an interface dysfunction. However, other sportspeople may develop a specific neural component to their problem and this is when treatment may be directed at the neural structures specifically in the form of slider or tensioner techniques. It is known that the two different techniques produce a difference in emphasis of forces in neural tissues<sup>22</sup>. Naturally, the slider produces less force in the nerves and more sliding and is therefore best suited to the athlete with an acute problem or one in which there is a need for the nerve to maintain its sliding capacity through myofascial structures as healing

occurs (Figure 8). The tensioner emphasises the elongation of nerve tissue and is more likely to provoke symptoms. Therefore it is often used in the higher function athlete with a smaller neural component to the problem (Figure 9).

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**Figure 8:** Lumbar neural slider technique, lower forces and more movement of the neural tissues (Reproduced with permission from Elsevier, Oxford<sup>21</sup>).

**Figure 9:** Lumbar neural tensioner technique – greater elongation force in the neural tissues (Reproduced with permission from Elsevier, Oxford<sup>21</sup>).

**Figure 10:** Integration of myofascial technique with sciatic nerve mobilisation in the case of neural aspect to hamstring pain (Reproduced with permission from Elsevier, Oxford<sup>21</sup>).

In stating that a key aspect of the neurodynamics approach is integration of neural and musculoskeletal function, usually athletes present with a need for multi-structural treatment. In this case, manual technique can be combined with neural mobilisation. This is particularly relevant to hamstring disorders (Figure 10).

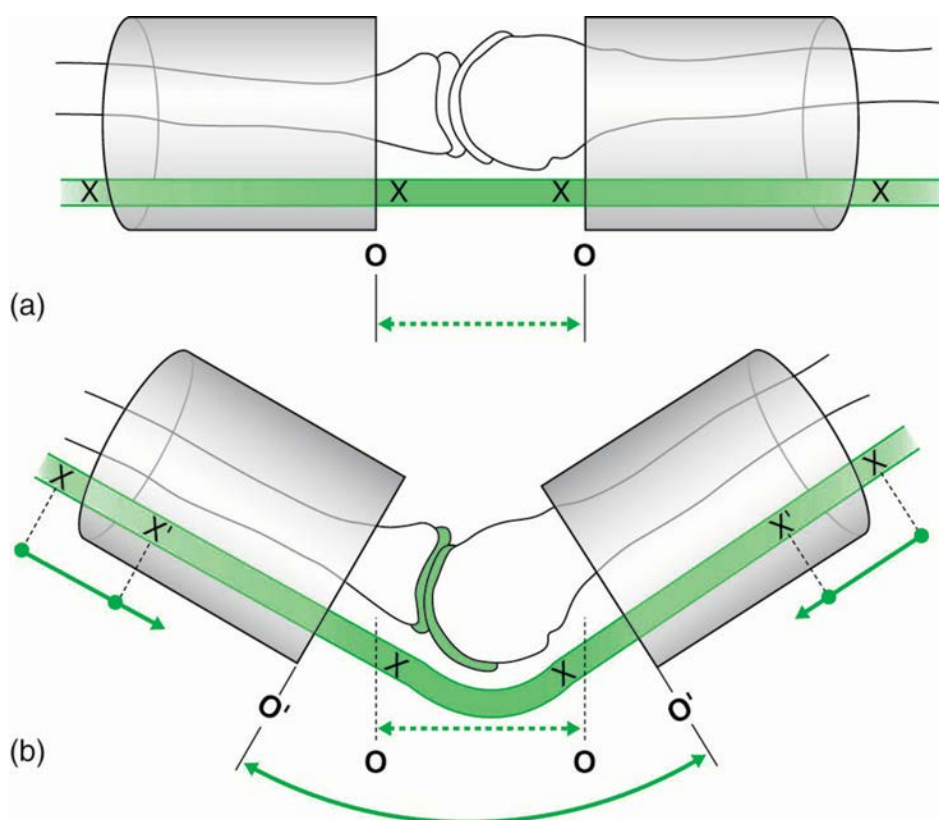
#### *Convergence*

This is a generic mechanism in that it occurs in all areas of the body when a joint moves. It is when the nerves slide toward the joint at which tension is applied (Figure 10). When joints are moved, this applies force to the adjacent nerves, which then produces relative displacement of nerves relative to the interface. This is a protective mechanism and actually gives clinicians opportunities in relation to a phenomenon which has been researched and applied clinically since the 1980s<sup>23</sup>. The clinical corollary is 'neurodynamic sequencing' which provides new opportunities to move the nervous system in ways that are more specific to the patients' needs. This is because the sequence of movement influences the movement and strain behaviour of the nerves which, in treatment, can be used to produce patients' relieving or symptomatic movements.

#### *Neurodynamic sequencing*

Even though the nervous system is a lengthy continuum<sup>4</sup>, its biomechanical function is not uniform. Instead, areas of high and low pressure and tension occur with daily movements and neurodynamic testing<sup>10,21</sup>. Shacklock<sup>23</sup> showed that, in asymptomatic subjects, the order or sequence of application of the component movements of the same neurodynamic test affected the distribution of symptoms. More symptoms tended to develop in the local area where the joint was moved first and more strongly. These results were derived by comparison of three studies in which the above variables occurred<sup>23-25</sup>. The effects of the sequence of movement on the upper quarter have also been investigated with the result that fewer responses occur in the area that is moved last<sup>26</sup>. This phenomenon has support in cadavers in which the ulnar nerve was tested in three different sequences of movement<sup>27</sup> (Figure 12):

1. Proximal-to-distal sequence.
2. Distal-to-proximal sequence.
3. Elbow first sequence.



**Figure 11:** Convergence of nerve toward the joint at which tension is applied as a generic adaptive function of the nervous system (Reproduced with permission from Elsevier, Oxford<sup>21</sup>).



**Figure 12:** Measurement of strain in the ulnar nerve at the elbow during different sequences of movement in the cadaver. The sequence which produced most strain in the nerve was the one in which elbow movement was performed first (Reproduced with permission from Tsai 1995<sup>27</sup>).

The elbow first sequence produced significantly more strain (i.e. local effects) in the ulnar nerve at the elbow than the other two sequences of movement.

Since the sequence of movements has now been shown to influence the response and local strain in neural tissues, movement

sequencing is now an important variable in neurodynamic testing and treatment. This is called 'neurodynamic sequencing'<sup>21</sup> and relies on the principle that the nervous system does not behave uniformly and instead responds to movement in a variable way, depending on the local anatomy,

biomechanics and applied movements. Neurodynamic sequencing has several key benefits:

- Opportunity to test and treat in a way that is specific to the patient's movement-related needs, as opposed to simply relying on standard neurodynamic tests.
- A progressional system that can be applied to patient problems ranging from the patient who is very restricted and painful to the patient with a minor problem whose needs are quite athletic.

In two more recent studies of the median and sciatic nerves in cadavers, it was found that a nerve is under tension for longer during a neurodynamic test when the local joint is moved first<sup>28,29</sup>.

## SUMMARY

The clinical neurodynamics approach came from advances in neural tension and neural mobilisation and now includes many more aspects than in the past. These include sliding, pressure changes (mechanics), intraneural blood flow, sensitivity (physiology) of neural tissues. Furthermore, diagnosis and treatment are integrated with musculoskeletal function, particularly diagnostic categories and progressions in relation to technique selection. The benefits of this approach are that, when combining the cornerstones of neurodynamics, many more techniques are now available, such that diagnostic and treatment techniques are more flexible and can be customised for each individual patient more than before. The principles of clinical neurodynamics can be applied to many clinical syndromes, particularly including sports injuries and their management. Furthermore this approach can be applied to exercises, movement and performance-based strategies in the sportsperson and athlete.

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Michael Shacklock F.A.C.P., M.App.Sc., Dip. Physio.  
 Director, Neurodynamic Solutions (NDS)  
 Adelaide, Australia  
[www.neurodynamicsolutions.com](http://www.neurodynamicsolutions.com)