

On The Origin of Atraumatic Neuromusculoskeletal Pain

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ABSTRACT

The purpose of this study was to examine the possible origins of non-specific or atraumatic back pain by applying the Gate Theory of pain and current physiologic concepts. I present a theory that accounts for the initiation and potential consequences of neuromusculoskeletal pain incorporating failure of the mechanism of muscle relaxation and resulting in pain and compromise of the lymphatic system. The theory provides an alternative to current theories and hypotheses of the cause and consequences of neuromusculoskeletal pain.

Keywords: Pain; Muscular System; Muscle Relaxation [Chiropr J Australia 2016;1(1):1-8]

INTRODUCTION

The incidence of low back and other neuromusculoskeletal pain continues to increase, with low back pain being the leading cause of disability in the world(1, 2). In addition to the loss of quality of life for those experiencing musculoskeletal pain, the cost to both patients and society is significant and increasing:

- The annual cost of chronic pain in the United States, including healthcare expenses (direct medical costs), lost income, and lost productivity, is estimated to be \$635 billion. This is significantly higher than the estimated annual costs in 2010, dollars of heart disease (\$309 billion), cancer (\$243 billion), and diabetes (\$188 billion).
- Total estimated medical costs associated with back and neck pain, two of the commonest presentations of patients with chronic pain, increased by 65% between 1997 and 2005, to about \$86 billion a year. Overall, pharmaceutical expenditures related to back and neck pain increased by 188% between 1997 and 2005, but costs associated with prescription narcotics rose by an astounding 423%.
- In the US, the estimated annual direct medical cost of low back pain is \$30 billion. In addition, the impact of back pain is \$100-200 billion in decreased wages and lost productivity while in Australia, the direct cost of is estimated to be AU dollars 1.02 billion in 2001. And the indirect costs of AU dollars 8.15 billion giving a total cost of AU dollars 9.17 billion (3).
- Patients with chronic pain have more hospital admissions, longer hospital stays, and unnecessary trips to the emergency department. (4)

Musculoskeletal pain resulting from trauma such as whiplash, repetitive strain injury and heavy lifting is relatively easy to understand; however, the cause and, therefore, best treatment for acute or chronic nonspecific musculoskeletal complaints i.e., those complaints that have no known underlying pathology, is elusive. For example, it has been estimated that 90% of low back pain is classified as non-specific (5). Recasting neuromusculoskeletal dysfunction in light of current pain theory has resulted in the identification of a possible

underlying cause or initiating event of non-specific or atraumatic musculoskeletal pain.

Serious study of the phenomena of pain did not begin until the 1960s. In 1965, Melzack and Wall published the Gate Theory of Pain (6). The Gate Theory of pain has undergone thorough and extensive testing at all levels and currently represents the generally accepted view of the perception of pain (7). Recent research has identified specific interneurons in the dorsal horn of the spinal cord that perform the function of the "gate" (8). The Gate Theory serves here as a framework for development of insights into the underlying phenomena of non-specific musculoskeletal dysfunction and its accompanying pain.

Within this framework, it is key to recognize that the perception of pain is not always due to an increase in nociception. Reduced proprioceptive input to the CNS will also result in pain by creating an apparent increase in nociceptive input and this was recently demonstrated experimentally through selective disabling of the specific interneurons of the gate(8). A mechanism of muscle dysfunction that results in a reduction of proprioception thereby altering the balance between nociception and proprioception, would provide an explanation of atraumatic pain.

Understanding muscle dysfunction is predicated on an understanding of normal muscle function. In normal muscle, contraction of individual muscle fibers is initiated through the action of large myelinated nerve fibers which innervate several to hundreds of fibers. Each nerve branch terminates close to the middle of the individual muscle fiber with multiple branches which form the motor end plate. Excitation of these nerve fibers results in the release of acetylcholine which, in turn, open acetylcholine gated channels in the muscle membrane. The opening of these channels allows sodium and calcium ions to rapidly pass to the inside of the muscle membrane and depolarize the membrane, resulting in muscle contraction through the generation of an action potential which travels in both directions from the center of the muscle fiber toward each end(9).

Depolarization of the surface membrane of the muscle fiber as described above is accompanied by the release of calcium ions from the sarcoplasmic reticulum which cause contraction of the myofibrils resulting in contraction of the muscle fiber itself. Relaxation of the muscle fiber is enabled by the adenosine triphosphate (ATP) energized calcium pump, which returns calcium ions to the sarcoplasmic reticulum where they are available for the initiation of the next muscle contraction (9). If the calcium pump malfunctions, the muscle cannot relax. A failure of the calcium pump would account for the inability of a muscle

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fiber to relax, reducing proprioceptive input to the CNS from the sensory organs of the muscle fiber or fibers involved independently of motor nerve input.

Statement of the Neurochemical Theory of Musculoskeletal

Dysfunction

The theory of neuromusculoskeletal dysfunction presented here is comprised of:

- An acute stage consisting of an initiating event wherein a portion of muscle mass in a normal contractile state is prevented from extending or relaxing due to a local failure of the calcium pump. The inability of the muscle to relax results in the reduction of proprioceptive input to the CNS and the perception of pain.
- If the muscle dysfunction is not immediately corrected, the initial muscle dysfunction will result in compromise of the lymphatic system resulting in potentially serious and poorly understood consequences for the health of the individual. Such consequences may include but are not limited to: localized edema, decreased blood flow, production of abnormal products of cellular metabolism and other potentially serious health effects. (Figure 1)

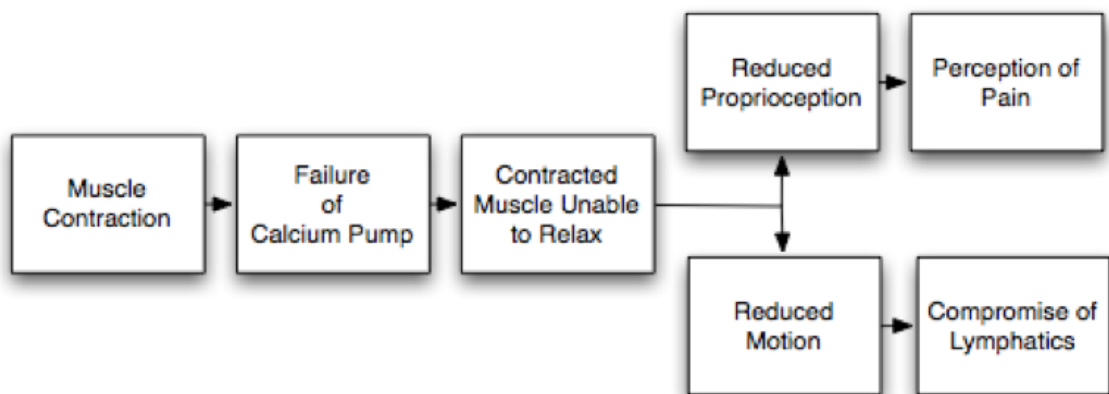


Figure 1. Diagram of neurochemical hypothesis of atraumatic neuromusculoskeletal pain.

DISCUSSION

The theory of neuromusculoskeletal pain presented here incorporates features rendering the theory unique compared to other attempts to explain non-specific musculoskeletal pain. Among these features are:

- A failure of the ATP powered calcium pump, which is fundamental to muscle relaxation, is proposed as the initiating event of atraumatic musculoskeletal pain.
- That cessation of proprioception from constricted muscle mass to the CNS is the cause of acute musculoskeletal pain rather than the view that intense proprioception is the cause of pain;
- That muscle dysfunction in the form of persistent contraction leads to compromise of the lymphatic system.

The theory proposed here combines known processes and functions to create a basic building block that may arguably be combined with other components of skeletal function to represent the allopathic trigger point, the osteopathic lesion, the chiropractic subluxation the physical therapy movement restriction and the cardiologist's myocardial infarction (10-13).

The fact that the function of the calcium ion pump in muscle relaxation is not cited elsewhere in the literature as a possible cause of muscle constriction and consequent pain may be explained by the focus on increased nociception through injury or trauma as the primary cause of muscle pain and the relative neglect of the role of calcium in membrane depolarization coupled with the emphasis on the concept of "facilitation" proposed by Korr (14).

The seminal work of Huxley and Stampfli (15) which identified the sodium-potassium pump and the role of these ions in nerve membrane depolarization was based on the study of axons of squid and giant mollusks which is not totally applicable to vertebrates. In his review of the history of the discovery of the role of the calcium ion in vertebrates, Tsien (16) attributes the dominance of the sodium-potassium paradigm as the main factor inhibiting the field of ion channel exploration for over forty years. The fundamental role of calcium in the nervous system has only recently been appreciated. In fact, a Nobel Prize was awarded for the discovery of the role of calcium ion channels in synaptic communication as recently as 2013. (<http://med.stanford.edu/news/all-news/2013/10/the-science-behind-thomas-sudhofs-nobel-prize.html>)

Recent work utilizing x-ray diffraction has clarified details of the structure and function of the calcium pump Toyoshima (17,18). These studies have revealed that not only ATP and calcium but also magnesium, phosphorous, sarcolipin, as well as the maintenance of pH are necessary for the function of the pump. Toyoshima(17) in fact, expressed surprise that the failure of the calcium pump has not been recognized as being related to more disease states:

"Because Ca^{2+} is so fundamental in the regulation of biological processes,

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malfunction of Ca^{2+} pumps is likely to be deleterious to living organisms.” A major consequence of the theory presented here is that muscular dysfunction results in a compromise of the lymphatic system. Once the muscle or portion of muscle becomes unable to relax, the lack of movement within the structure of the muscle reduces the drainage of lymph from the cells of the muscle. If the lymphatic system is severely compromised, the cellular metabolism of the affected muscle volume will be altered. While not as dramatic as failure of the cardiovascular or respiratory systems, failure of the lymphatic system can result in serious consequences, even death within 24 hours (9). Maintenance of the health of the lymphatic system through prevention of compromise of that system by muscle constriction may be the most powerful argument for regular visits to providers skilled in manual therapy.

As predicted by Travell (19), failure of the muscle to relax should result in a reduction of the blood flow through that portion of the muscle. Such an effect has been measured in the case of active myofascial trigger points (aMTPs) where abnormal blood velocity measures were found to distinguish between active and latent myofascial trigger points (20-22). The resulting ischemia is likely to result in the generation of recently discovered and as yet poorly understood inflammatory agents which trigger the innate immune system producing increased nociception and therefore increased pain. Since this immune reaction is not associated with invasion of the body by pathogens, this type of inflammatory response is referred to as “sterile” inflammatory response and is associated with mechanical trauma, ischemia, stress and environmental factors (23). The inflammatory agents expressed which trigger the sterile inflammatory response are known as danger associated molecular patterns (DAMPs)(24) and include substances such as cytokines, $\text{IL-1}\beta$ and IL-18 , along with the DAMP High Mobility Group Box 1 (HMGB1). With regard to the theory described here, the sterile inflammatory response would appear to be a secondary result of the initial failure of muscle relaxation. Therefore, an expected result of manual therapy that succeeds in reversing the initial muscle dysfunction would also be expected to reduce the levels of DAMPS in the circulation. Evidence in support of this proposition is found in the work of Teodorczyk-Ineyan et.al. (25) who concluded that spinal manipulative therapy was associated with down regulation of inflammatory responses “via a central yet unknown mechanism.”

CONCLUSION

By starting with the Gate Theory of Pain and applying current knowledge of basic physiology to the problem of back pain, we have arrived at a potentially useful new hypothesis regarding the likely cause of atraumatic back pain. Rather than concluding that all back pain is the result of tissue injury caused by overuse, buckling, trauma, or an aberrant neurological feedback that maintains muscles in a continuous state of contraction, a failure of the mechanism that permits muscle relaxation to occur is proposed. Not being able to exit the contracted state, the normal proprioceptive feedback associated with the involved muscle will be absent resulting in an excess of nociceptive input to the Gate resulting in the perception of pain. Compromise of the lymphatic system due to lack of normal muscle function may follow. This hypothesis is supported

by existing experimental evidence and appears to have broad implications for diagnosis and treatment of conditions extending far beyond the immediate problem of back pain.

The theory presented here provides an alternative to current theories and hypotheses of the cause and consequences of musculoskeletal pain. The theory provides useful insights for the improvement of therapeutic modalities not only for relief but also prevention of pain and maintenance of a healthy neuromusculoskeletal system. The key features of the theory are the initiation of pain through the inability of muscles in a state of contraction to relax due to a failure of the ATP-calcium pump and the compromise of the lymphatic system through the reduction of lymph flow.

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