Integrating osteopathic approaches based on biopsychosocial therapeutic mechanisms. Part 1: The mechanisms

International Journal of Osteopathic Medicine. 2017;25:30-41.
http://dx.doi.org/10.1016/j.ijosm.2017.05.002

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ABSTRACT

This article reviews and discusses the biological and psychological mechanisms that may be responsible for therapeutic effect in an osteopathic therapeutic encounter. Although many of the reviewed mechanisms require additional high-quality evidence, osteopathic treatment may reduce pain and improve movement and function from a 'bottom-up' influence on tissues and tissue receptors and from a 'top-down' influence on cognitive and psychological states. Osteopathic models and manipulative technique have traditionally emphasized tissue and biomechanical mechanisms, but this emphasis is misplaced given the paucity of clinical evidence for these effects. In recent decades, growing evidence supports the importance of neurological and psychosocial factors in musculoskeletal pain, making the 'biopsychosocial' model of pain management a mainstream consideration for the management of pain. This article proposes that both biological and psychosocial therapeutic mechanisms may contribute to therapeutic effect and that tissue and neurological effects on pain and motion, albeit small and temporary, may complement cognitive reassurance and education to promote improved confidence and control in movement. Judgement of the dominating factors will help determine the clinical approach. Part 2 will explore the clinical approaches that arise from an understanding of the mechanisms likely involved in manual therapy.

Keywords: biopsychosocial; therapeutic; manual therapy; osteopathic manipulative treatment

INTRODUCTION

Osteopathic manipulative treatment consists of a wide range of manual therapy techniques that are used to optimise function and reduce pain. Osteopaths typically treat people for musculoskeletal pain, most commonly back and neck pain, and for the promotion of general health and treatment of some health conditions [1, 2]. Manual therapy is the mainstay of osteopathic treatment for most patients, but osteopaths may also offer advice on posture, ergonomics, exercise, and lifestyle in conjunction with reassurance and encouragement to be active. This paper will refer to osteopathic treatment as the entire therapeutic encounter. Although more high-quality research is needed to verify the effectiveness of osteopathic treatment for many conditions, growing evidence suggests clinically relevant effects for the osteopathic treatment of low back and neck pain [3, 4] and for other conditions [5].

The biopsychosocial framework for treating chronic pain has gained wide acceptance and has largely replaced the biomedical framework. The biopsychosocial framework refers to the interaction of physical, psychological, and social influences which contribute to pain and disability, and a biopsychosocial approach to treatment should address these factors [6-8]. In recent decades, evidence supports the influence of the central nervous system (CNS) and psychological influences on chronic pain, whereas the evidence for tissue, postural, or biomechanical causes of chronic pain is scant.

Osteopathy has a biomedical heritage, and osteopathic manipulative treatment developed within a biomechanical paradigm. This cultural and philosophical heritage is likely to still be strong in the profession, both for practicing osteopaths and in osteopathic educational institutions. For example, osteopathic texts typically describe manipulative techniques in terms of altered biomechanics and restricted motions to be corrected [9-11], and

osteopaths are more likely to explain a person's pain in pathological and biomechanical terms rather than in neurological or even psychosocial terms.

The current article aims to provide an overview of the likely therapeutic mechanisms responsible for improvement in somatic pain and function following osteopathic treatment. Pain and impaired movement in most people will be associated with a combination of biological and psychosocial origins, and osteopaths need to consider the balance and dominance of these factors and construct a management plan that addresses the physical and psychosocial components. Clinical evidence of changes to the tissues following treatment is scarce, and available evidence mostly provides a rationale for potential tissue therapeutic mechanisms. Given this, the tissue effects of treatment likely play a smaller role in the therapeutic effect than the neurological and psychological influences for most people. The current article will present a case for the potential influence of mechanisms affecting the tissues, nervous system, and psychology of the person, where the relatively small tissue influence may help modify pain and increase movement in the short-term and achieve longer lasting improvement in pain and movement largely by neurological and psychological mechanisms that desensitize the painful movement and promote improved motor control.

The evidence for psychosocial influences on pain largely draws on evidence from low back pain (LBP); however, the current article aims to provide a framework for the treatment mechanisms relevant to pain of somatic origin from any region. Thus Part 1 will explore and discuss the likely mechanisms for therapeutic effect of osteopathic treatment, and Part 2 will explore the clinical approaches when identifying and treating the pain processes underlying a person's complaint with somatic pain and movement impairment.

MECHANISMS OF PAIN

Osteopaths should understand the mechanisms of pain because acute and chronic pain involve different processes. Acute pain is defined as pain of three months or less duration that is predominately of nociceptive origin from the tissues, where tissue injury creates inflammation that activates nociceptors producing the experience of nociceptive pain [12, 13]. Pain is a conscious perception that is modified by fear, anxiety and previous experience. The brain responds to the perception of danger or threat, rather than the actual stimulus, and will enhance perception of pain when a noxious stimulus is perceived as a threat [14].

With chronic pain, the source of pain shifts from nociceptive pain to pain produced by sensitization of CNS pathways. When the nociceptive stimulus is intense or persistent, neuroplastic changes occur in the second order neurones of the spinal cord dorsal horn and in the higher centres of the CNS, producing a prolonged increase in the excitability and synaptic efficacy of neurons in central nociceptive pathways [12]. Functional and anatomical reorganisation in the dorsal horn and higher centres of the CNS produce prolonged nociceptive pathway amplification. The exaggerated pain response to stimuli may outlast the original tissue injury, resulting in the pain transitioning from a nociceptive basis to a purely CNS origin. The underlying neuroplastic processes of central sensitization have been well described elsewhere [12, 13]. Although central sensitization may be the dominant process in chronic pain, there may still be peripheral noxious drivers present. Central sensitization is a significant component of pain in subgroups with osteoarthritis [15] and shoulder pain [16]. The experience of chronic pain likely involves a mix of nociceptive and central sensitization input for many people.

As pain becomes chronic, brain representation of pain shifts from nociceptive and discriminatory sensory to emotional circuits [17]. Activity in pain-related areas of the brain, such as the insula, anterior cingulate gyrus, and thalamus, diminishes and emotion-based brain circuits involving the medial prefrontal cortex, amygdala, and basal ganglia grow in

strength [17, 18]. Together with sensitization, cortical disinhibition, where intracortical inhibition is lost or reduced, affects the organisation of the cortex and the sensory and motor representation of body parts to potentially disturb proprioception and motor control [14]. Further, psychosocial factors play an important role in acute LBP [19] and in the transition to chronic pain and may contribute at least as much to chronicity as other clinical factors [20].

Osteopaths should recognise that chronic pain may be the product of long-lasting changes in central sensitization of the spinal cord and no longer have any tissue or nociceptive origin. There may also be a mix of central sensitization and peripheral nociceptive inputs, and although the sensitization changes may be difficult to reverse, there is evidence from hip and knee replacement studies that once the peripheral nociceptive driver is removed central sensitization can diminish [21]. The clinical features of central sensitization pain are widespread hyperalgesia, where normally painful stimuli produce exaggerated pain; allodynia, where normally non-painful stimuli, such as light touch or motion, produce pain; and a general increase in responsiveness to a variety of other stimuli [22]. These changes may become persistent and pose major challenges for patients and osteopaths alike, particularly if both are convinced that the source of symptoms is due to tissue damage and requires a biomechanical approach to treatment.

POTENTIAL THERAPEUTIC MECHANISMS

Osteopathic treatment may influence a variety of biological and psychosocial factors to help patients with acute or chronic somatic pain and impaired movement (Figure 1). Lederman [23] described the effects of osteopathic treatment as occurring in three dimensions: tissue, neurological, and psychological dimensions. The current author believes that this model is useful to conceptualise key areas of potential influence, where the ‘bio’ of biopsychosocial relates to tissue and neurological dimensions and the ‘psychosocial’ relates

chiefly to psychological dimensions. Many of the following proposed therapeutic mechanisms are speculative and based on a rationale with supporting laboratory, but not clinical, evidence. In general, mechanisms affecting the tissues and biomechanics have the most tenuous evidential support and are largely speculative, in contrast to the emphasis of most technique texts on osteopathy [9-11].

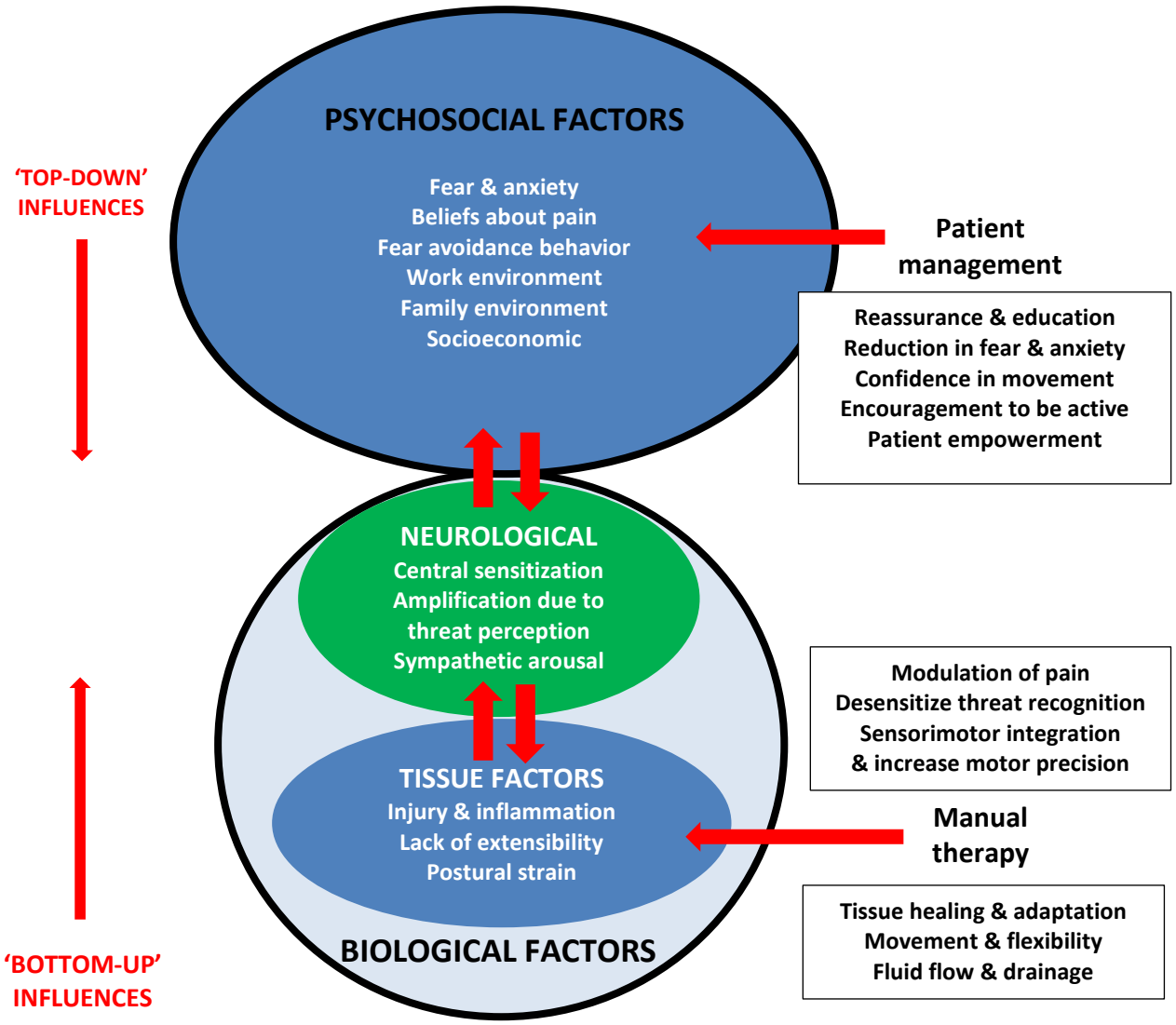

Figure 1. Psychosocial and biological factors in somatic pain and aims of osteopathic management

The potential influence of manual therapy on tissue mechanisms includes promoting tissue healing, movement, and tissue fluid drainage. In the neurological dimension, osteopathic treatment may produce 'bottom-up' changes by stimulating tissue receptors and ascending afferent activity to promote pain modulation at the dorsal horn or higher CNS and facilitate sensorimotor integration, interoception, proprioception, and motor control. In the psychological dimension, osteopathic treatment may reduce pain and encourage function through reassurance, education, psychological approaches to pain management, improved confidence, and empowerment. These changes in cognition and psychological state produce 'top-down' changes in pain modulation from the higher CNS and are likely to be important in desensitising painful behaviours and movements for long-term change. The biological and psychological spheres of influence are interrelated, and treatment that affects mechanisms in one area will likely produce changes in others (Figure 1).

Biological mechanisms

Biological therapeutic mechanisms include those mechanisms that affect the peripheral tissues, such as muscles, connective tissue, joints, fluids, and vessels, and those that involve the nervous system. However, the evidence for lasting change in the biomechanical properties of tissues from manual therapy is scant, and most mechanisms are speculative and based on experimental laboratory evidence.

Mechanisms affecting the tissues

Much of the evidence supporting physiological changes to tissues, such as promotion of connective tissue healing, reduction in fibrosis, increase in fluid drainage, and modulation of inflammation, is experimental and involves in vitro or animal model research. This evidence provides a plausible rationale for potential mechanisms, but lacks the clinical evidence from people treated with manual therapy. There is also positive but limited clinical evidence for changes in spinal range of motion [24-29], increased extensibility of

musculature [30-32], and influence on posture [28, 33-35], but again additional research is required to determine the clinical relevance of these effects. Data from primary experimental studies should not be used as proxy evidence for the effectiveness of treatment, and osteopaths should understand that the clinical relevance of most of the following biomechanical mechanisms is speculative.

Joint cavitation

In spinal manipulation, audible cavitation is associated with tribonucleation and the rapid separation of joint surfaces creating sustained gas cavities [36]. The resultant changes in joint pressure and volume allow the joint surfaces to separate more readily for a short period after the cavitation [37]. The decrease in resistance to joint separation following cavitation is only a temporary phenomenon, lasting approximately 20 minutes [36], and cavitation does not appear to be associated with reductions in pain [38, 39] or autonomic activity [39]. The temporary resistance to joint separation may allow subsequent techniques, such as passive joint articulation, to stretch the capsular tissues more effectively. However, this proposed treatment sequence is speculative, and it probably does not reflect the common clinical practice of performing spinal manipulation after other techniques.

Zygapophyseal joints often contain meniscoid-like synovial folds, and spinal manipulation may separate the joint surfaces to free an entrapped or extrapped synovial fold [37, 40]. This model is difficult to validate given that synovial folds are not easily visualised with imaging techniques, but they remain a plausible explanation for acutely ‘locked’ or restricted joints that respond to spinal manipulation [41]. Nonetheless, even if meniscoid extrapment in acute locked back can be experimentally demonstrated, the incidence and prevalence of this event, along with its diagnostic reliability, will still need to be addressed.

Stretch of joint and capsular ligaments

Passive joint articulation may feasibly stretch the joint capsule and surrounding periarticular soft tissues to produce viscoelastic changes, but long-lasting plastic lengthening with remodelling of collagen following articulation is only theoretical. Most studies that have reported increases in joint range following techniques, such as articulation and muscle energy technique (MET), have examined active range of motion; the mechanism for increased motion may be a change in stretch tolerance (pain inhibition by neurological mechanisms), as that which occurs when stretching muscles [30, 42].

Muscle extensibility

Few lasting changes in human muscle properties, such as stiffness or length, have been found following stretching techniques [43, 44]. Studies that have measured or controlled the pre- and post-force (torque) during stretching demonstrate little viscoelastic change after either passive or isometric stretching. These studies indicate that increased muscle extensibility is largely from the person's greater tolerance of an increased stretching force [30-32]. The key mechanism of increased muscle extensibility therefore appears to be sensory, rather than biomechanical, and the clinical significance of such changes are unclear.

Myofascial trigger points are claimed to be localised dysfunctions of myofascial tissue that are painful to palpation, refer pain in predictable patterns, restrict tissue extensibility, and are amenable to manual treatment [45]. Controversy exists regarding the aetiology and existence of trigger points because convincing evidence of a peripheral tissue lesion, such as a contraction knot, is lacking, and the reliability for detection of trigger point detection is variable [46-50]. There is evidence of abnormal motor endplate electrical noise [51] and of inflammatory chemicals in the interstitial tissues around trigger points [52]. However, the presence of inflammatory chemicals may be attributed to a CNS origin, rather than a peripheral origin [50], and evidence for increased tissue extensibility or clinical benefit following treatment of trigger points is lacking [49].

Promotion of tissue healing

When tissues are damaged, a cascade of events occurs to repair the tissues, including the production and organisation of new collagen. In tissues that are immobilised after injury, random collagen formation results in weaker and less extendible tissue; within joints, there is proliferation of fibrofatty connective tissue, adhesions between synovial folds, and atrophy of cartilage [53-55]. Movement and mechanical loading, such as occurs in passive and active movement, is essential for optimal healing of joints and adaptation of connective tissue [56-58]. Although active movement is preferable, pain, fear, and guarding restrict active movement in some people, and gentle manual therapy may have a role in promoting mobility, tissue extensibility, and active loading for improved healing.

Some authors [23, 59] have postulated that soft tissue techniques may improve tissue mobility by breaking collagen cross-links and connective tissue adhesions, and while these changes to connective tissue may be theoretically possible in healing tissue, mature adhesions are likely to be too strong to be affected by manual interventions [60]. From animal model studies, there is evidence of metabolic changes in fibroblasts and increased collagen fibrils following massage [61] and decreased nerve and connective tissue fibrotic changes following modelled manual therapy [62]. This experimental evidence provides a rationale of how manual therapy could potentially promote healing in recently injured, healing tissue, but this has not yet been investigated in humans and must be regarded as speculative.

Recently, the complex multi-layered structure of deep fascia and the role of the thin loose connective tissue layers within it have been highlighted [63]. The loose connective tissue permits the sliding of denser fascial layers, but alteration in the viscosity of the loose connective tissue can occur in overuse syndromes and from other factors [63]. The increase in density, known as ‘densification’, likely affects the sliding system of fascial layers within the deep fascia [63, 64]. Stecco et al. [64] found increased thickness in the sternal ends of

scalene and sternocleidomastoid muscles in people with chronic neck pain, which was reduced following deep friction massage. This interesting research may eventually validate some of the immediate tissue changes perceived in clinical practice, but its clinical relevance is currently speculative.

Mechanotransduction and fibroblast responses

In recent years, there has been a growing interest in the influence of mechanical forces on biological control of fibroblasts at the molecular and cellular levels [65]. Ingber [65-67] has verified that cells and tissues have both tension and compression elements and have tensegrity properties, which allows mechanical forces to be distributed throughout the tissue and cells. Mechanical forces to connective tissue are transmitted to the cell nuclei of the fibroblasts, which may alter cellular biochemical activity and even gene expression in a process known as mechanotransduction [65]. Some authors have speculated that mechanotransduction explains many of the therapeutic effects of manual interventions [65, 68, 69] although few studies can be generalised to manual therapy.

Standley and colleagues [70-75] have used an in vitro tissue strain model to investigate the effects of repetitive tissue strain and subsequently applied 'modelled' osteopathic indirect technique on human fibroblasts. Following an 8-hour repetitive strain, a 60-second application of modelled indirect technique involving shortening the tissue appeared to reverse the inflammatory response of the previously strained cells, causing a reduction in pro-inflammatory interleukins and an increase in fibroblast proliferation [73]. Modelled myofascial release following repetitive tissue strain resulted in normalization of fibroblast apoptotic rate and cell morphology compared with repetitive tissue strain alone [75].

Other researchers have reported that massage therapy reduces inflammation and promotes mitochondrial biogenesis in skeletal muscle acutely damaged by exercise [76].

Stretching may also modulate inflammation-regulation mechanisms within connective tissue. In an animal model, stretching reduced inflammatory lesion thickness and neutrophil count and increased the concentrations of pro-resolving mediators within experimental lesions [77].

The basic science research on cell tensegrity and mechanotransduction provides intriguing possible cellular mechanisms for the action of manual therapy. The role of these mechanisms in producing clinical outcomes from manual therapy is currently highly speculative, and further research is needed before they can be used to verify their role in symptomatic people.

Effect on posture

The emphasis by manual therapists on assessing posture and postural symmetry has attracted criticism because studies have reported little association between postural factors and LBP [78] and the reliability for assessment of postural and anatomical asymmetry is poor [79, 80]. While it is clear that the historical emphasis on assessing postural factors has been misplaced, posture does appear to influence some musculoskeletal conditions, such as forward head posture with neck pain [81-83], foot posture with LBP [84], and mild leg length inequality with leg, pelvis, and trunk mechanics [85]. Conditions such as LBP and neck pain are typically multifactorial, and inefficient posture may be a contributing factor for some individuals [86]. There is evidence that manual therapy improves neck posture [28, 33], round shoulder posture [34], and lumbar sagittal imbalance and lordosis [35], but the longevity and clinical relevance of these effects remain to be determined.

Movement of fluids

Manual techniques produce joint movement, tissue stretch, and compression; and some techniques utilise active muscle contraction. These mechanical factors promote tissue drainage from the pressure-dependent vessels of the lymphatic and venous systems. Although speculative, manual techniques may promote improved fluid drainage in inflamed

joints, which may be helpful for reducing pain and increasing joint motion [87]. Flexion and extension of a zygapophysial joint have been shown to produce intra-articular pressure changes [88], and passive motion may promote increased trans-synovial flow to encourage synovial fluid movement across the synovium and out of the joint space. Where a joint has been injured and is inflamed or effused, manual techniques may promote the movement of fluid from the joint and the periarticular tissues. Removal of excess tissue fluid in the presence of inflammation may improve motion of the joint and reduce pain by removing inflammatory mediators [87].

Muscle contraction increases interstitial tissue fluid collection and lymphatic flow [89, 90]. Manual techniques that use voluntary muscle contraction, such as MET, may assist lymphatic flow and clearance of excess tissue fluid and pro-inflammatory chemicals, augment hypoalgesia, and reduce the intramuscular pressure and passive tone of the tissue. The plausibility of manual lymphatic drainage techniques is supported by animal models and by pilot and case studies, but high-quality evidence is required to confirm the effectiveness for lymphatic drainage [91]. However, active movement and exercise also promotes lymphatic flow and drainage [89, 90], and it is inexpensive and more empowering than passive treatment. Manual treatment for lymph drainage should be reserved for people who are immobile or present with localised conditions that may respond to specific, targeted techniques.

Lymphatic pump techniques of the chest and abdomen have long been used in osteopathy to promote lymph flow for systematic health benefits. Recent evidence from animal models suggests these techniques may not only increase lymphatic flow [92] and lymphocytes in circulation [93], but also augment the immune response [94]. Lymphatic pump techniques in animal models have also been reported to inhibit the growth of *Streptococcus pneumoniae* bacteria in the lungs [95, 96]. These animal studies suggest

potentially important health outcomes from lymphatic pump techniques, but their generalisability to humans is yet to be explored and should still be regarded as speculative.

Neurological mechanisms

Neurological models, such as Korr's facilitated segment [97-99], have been popular and enduring hypotheses for somatic dysfunction and the effectiveness of manual treatment in osteopathy [100]. However, the original research underpinning the facilitated segment had many shortcomings [101], and recent studies have not supported the electromyographic findings of Denslow and Korr [102, 103]. Further, a growing understanding of the neurological changes underlying chronic pain have necessitated a reconsideration of the influence of manual therapy and its role in pain relief. Substantial clinical evidence exists of the pain-reducing effects of manual therapy [104-107] on acute nociceptive pain, and basic research has shed light on the likely neurological mechanisms by which pain reduction occurs [108].

Modulation of pain by manual therapy

Pain modulation from manual techniques may occur from 'bottom-up' stimulation of tissue mechanoreceptors to affect the CNS, which in turn activates descending pain modulation systems [109-112]. Manual therapy produces a mechanical stimulus, and responses are conveyed from peripheral receptors to the CNS. Pain modulation may occur at the dorsal horn of the spinal cord, as first suggested by Melzac and Wall [113], such that sensory input from low-threshold A beta fibres inhibit incoming nociceptive input. Structures of the higher CNS, such as the rostral ventromedial medulla and periaqueductal grey, modulate nociceptive circuits and pain output [109], and descending modulation of pain from these structures is a likely mechanism in manual therapy. The periaqueductal grey is further implicated by indirect evidence of associated responses of hypoalgesia and sympathetic activity following manual therapy [110].

Sensory and proprioceptive changes

Chronic or persistent pain is associated with reorganisation of the primary sensory and motor cortices and other parts of the brain [14]. In chronic LBP, the primary sensory cortex representation of the affected area becomes larger, and there may be a decrease in grey matter in areas involved in pain processing [18]. Strategies to normalise sensory representation involving sensory stimulation and cognitive training have been described and require investigation [14].

Manual therapy may have a role in providing sensory stimulation and improving sensorimotor integration although the evidence is only currently emerging. Spinal manipulation of dysfunctional cervical segments has been reported to decrease somatosensory evoked potentials, suggesting that manipulation modifies sensory input to the CNS [114, 115]. Using functional magnetic resonance imaging, Gay et al. [116] reported changes in functional connectivity between brain regions that process pain following spinal manipulation, joint mobilisation, and gentle therapeutic touch over the sacrum. However, therapies that actively engage the person, such as proprioceptive training and mirror visual feedback, are more likely to produce lasting changes in sensorimotor integration and motor control than passive treatment [117, 118]. Additionally, some authors have proposed that osteopathy may reduce sensitization by affecting interoception, the representative process of body sensations coming from the body itself, which may be altered by chronic pain [119].

Influence on the motor system

Historically, manual therapy authors have proposed that pain and dysfunction cause increased motor activity, which manifests either as palpable ‘spasms’ or disturbed normal motion [120]. Muscle spasm and reflex muscle relaxation from manual therapy are popular notions, but ones with little supporting evidence [120]. Despite dated claims of abnormal muscle electromyography (EMG) associated with palpable ‘dysfunction’ in resting tissue

[121], modern studies have failed to reveal any such abnormality [102, 120, 122]. In people with LBP, both increased and decreased EMG activity have been reported, and these EMG responses are seen as complex changes in motor strategy that attempt to reduce load on the painful tissues [120, 122].

The effect of manual therapy on EMG activity of paraspinal muscles is still unclear. Studies that have examined manual techniques on low activity or resting conditions have found conflicting results. Using surface electrodes to examine the superficial muscles, researchers have reported short-lived EMG responses from paraspinal muscles during and after spinal manipulation [123], which appear to be related to the force [124] and speed [125] of the application, but the clinical relevance of these short-lived responses is unknown. Other researchers using surface EMG have reported reductions in paraspinal EMG in muscles that appeared taut to palpation after spinal manipulation [126-128]. When using intramuscular electrodes to investigate the deep paraspinal muscles underlying palpably tender and taut regions, resting EMG appears largely unchanged following manual techniques [103].

The effect on dynamic movement following spinal manipulation appears more promising. Alterations in the flexion-relaxation response of lumbar paraspinal muscles in people with LBP have been well established [129], and some studies have reported improvements in paraspinal relaxation during the flexion-relaxation phase following spinal manipulation [130-132]. Changes in activity of the deep paraspinal muscles following manual therapy appear complex, and reports include increased recruitment of the oblique abdominal muscles, but not of the multifidus muscles [133], and reduction of multifidus activity despite greater trunk rotation force [134].

Musculoskeletal pain is associated with reorganisation of the primary sensory and motor brain, and these changes increase with the chronicity of pain [14]. Recent studies have reported that individuals with recurrent pain have increased excitability of motor neurons and

less distinct topographical representation, or ‘smudging’, of different muscles in the primary motor cortex [135-137]. The effect of manual therapies or other interventions on these pain-related changes to the motor brain are unknown. Manual techniques, such as spinal manipulation and muscle energy, have been reported to produce immediate reduction of motor cortex excitability [138, 139], but the longevity and clinical importance of these changes are speculative.

Pain disturbs proprioception and motor control [135-137, 140-146]. Individuals with chronic neck pain have been reported to have jerky and irregular cervical motion [140] and poorer position acuity than healthy controls [140-143]. People with neck pain also demonstrate greater postural sway [144], a characteristic shared by people with LBP [145, 146]. The evidence for manual therapy improving proprioception and motor control is limited, but studies have reported reduced repositioning error [147-150] and improvements in postural sway [151] immediately following manual therapies. Although further investigation is warranted, manual therapy may promote sensorimotor integration, proprioception, and motor control. However, active interventions more likely influence sensorimotor integration than passive approaches [117], and active approaches, such as proprioceptive training and exercise, should be included in the management of such people.

Autonomic nervous system responses

There are long-held propositions in osteopathy that pain and dysfunction produce increased segmental sympathetic nervous system (SNS) outflow, which impacts innervated viscera adversely, and that manual therapy reduces this abnormal SNS outflow [98, 152]. However, little evidence supports the proposal of abnormally increased SNS associated with musculoskeletal dysfunction [100] (other than complex regional pain syndrome [153], a condition of sympathetic dysfunction), and conflicting evidence exists regarding reduced

SNS outflow following manual therapy. Nonetheless, pain activates the SNS [153], and any treatment which decreases pain should also decrease the abnormal state of SNS arousal.

Contrary to expectation, manipulation and mobilisation produce short-term *increases* in SNS outflow. In a review of the autonomic effects of spinal mobilisation, Kingston et al. [154] concluded that mobilisation consistently produced a sympathetico-excitatory effect on skin for SNS outcome measures, such as skin conductance, respiratory rate, blood pressure, and heart rate, irrespective of the site of mobilisation. A higher rate of mobilisation (i.e., more rapid) produced greater changes in skin conductance [155]. Zegarra-Parodi et al. [156] reviewed the effect of spinal manual therapy on skin blood flow and found most studies reported a sympathetico-excitatory effect, but definitive conclusions were difficult because of the heterogeneous nature of the studies and the multiple influences on skin blood flow. Spinal manipulation and lumbar extension exercises have both been found to produce immediate increases in SNS activity, with spinal manipulation producing greater changes [157, 158].

In contrast, several studies have reported that osteopathic techniques produce an immediate parasympathetic nervous system response using heart rate variability as a measure of autonomic balance [159-161]. In each of these studies, the manipulative techniques performed were gentle and relaxing and included soft tissue techniques to the upper cervical musculature [159, 160] or a combination of balanced ligamentous technique and craniosacral techniques [161]. Given the relaxing nature of these techniques, it is not surprising that a general parasympathetic response was produced.

Manual techniques, such as spinal mobilisation and manipulation, appear to have a short-term sympathetico-excitatory effect that is not localised to the treated region or likely mediated by local spinal reflexes. Gentle techniques directed at the cervical musculature produce a parasympathetic response. The longevity or clinical significance of these effects

has not been established, but a profound parasympathetic response may augment wellbeing when combined with reassurance from the practitioner.

Psychosocial mechanisms

Psychological factors play an important role in acute LBP [19] and in the transition to chronic pain. Psychological factors, which include beliefs and behaviours that may reinforce inappropriate or passive behaviour or produce obstacles to recovery, may contribute at least as much to chronicity as clinical factors and physical findings [20]. For example, decreased catastrophising instead of improved abdominal muscle contraction was found to be more useful for predicting positive outcomes in LBP following treatment with spine stabilization exercises [162]. Social factors, such as low socioeconomic background, poor education or literacy skills, and unsupportive work or family environment, should be recognised because they may contribute to disability and chronicity [163], but since these social factors often involve organisations and systems, they are less amenable to change in an osteopathic therapeutic encounter.

Psychological interventions, specifically cognitive behavioural therapy (CBT), appear to be useful for managing chronic pain, although the benefit is relatively small and is unclear for people with neck pain [164, 165]. CBT has also been shown to provide small benefits for pain and disability in people with fibromyalgia [166] and children and adolescents with headache [167]. Importantly, multidisciplinary treatments that target psychological and social aspects of LBP as well as physical aspects result in larger reductions in pain and improvements in daily function than usual care or treatments aimed only at physical factors [6].

Practitioners should be alert to persons with emotional distress on initial consultation because this distress may result in an increased number of consultations if not addressed [168]. There is strong evidence for the role of distress and depressive mood in the transition

from acute to chronic LBP [20] and weaker evidence for fear of pain [169]. 'Yellow flags' are used by clinicians to identify psychosocial prognostic factors for the development of disability following the onset of pain and include fears about pain or injury, unhelpful beliefs about recovery, passive attitude to rehabilitation, catastrophising, and distressed states, such as despondency [170].

Clinicians can have a strong and enduring influence on a person's beliefs concerning their pain and injuries [171, 172]. This influence may shape those beliefs to reduce fear and anxiety, or it may inadvertently reinforce non-productive beliefs and behaviours and disability [173]. Pain education that involves an explanation of the neurobiology of pain [174] can have a positive effect on pain and disability [175]. Positive messages, such as the spine is strong and activity is healthy, and education and reassurance are important to reduce fear behaviours and to empower the individual to take a more active role in their management. Cognitive reassurance aims to change perceptions and beliefs through education and appears to be more beneficial for reducing concerns and enabling the person than affective reassurance, which aims to reduce worry and reassure people through a sense of being cared for and understood [176]. To achieve better communication skills and reassurance, clinician training does not need to be extensive. In one study, an 8-hour training session focused on supporting peoples' psychological needs improved the support given by physiotherapists compared with physiotherapists who did not undergo the training [177]. In a systematic review, Traeger et al. [178] found moderate- to high-quality evidence that education can provide long-term reassurance for people with acute or subacute LBP.

Psychological factors can also contribute to the non-specific effects of manual therapy treatments. The specific effects of treatment relate to the specific action of the intervention, whereas the non-specific effects, often referred to as placebo, relate to a variety of factors that influence the context of the treatment environment [179]. The impact of non-specific effects

may vary from individual to individual. The clinician's influence in the patient-practitioner interaction can be perceived by patients to relate to a mix of interpersonal factors, such as communication skills and empathy; clinical factors, such as expertise and level of training; and organisational factors, such as the practice environment and setting [180]. Research is required to determine which of these factors are most influential. It makes sense to maximise the non-specific effects of treatment, but in a manner that is ethical and promotes patient-centred care, reassurance, and empowerment.

Specific CBT approaches may be highly complementary with osteopathic care. One such approach to chronic pain is Acceptance and Commitment Therapy (ACT), which aims to increase psychological flexibility and focuses on improving function. In a systematic review, ACT had positive effects on chronic pain, depression, anxiety, pain intensity, physical functioning, and quality of life [181]. ACT has been suggested for use by manual therapists [182] and, although it would require additional training, this approach might allow osteopaths to deal more effectively with chronic pain patients.

Treatments that target psychological aspects of LBP are more effective than just physical therapies, and the psychological influences may be more substantial than the specific tissue or neurological effects for many people [6]. Clinicians must be cognisant of their influence to help or harm people by use of their language and messages conveyed to the patient. Clinicians should provide reassurance and positive messages and aim to harness the non-specific effects of the therapeutic encounter to produce a helpful and positive context that will enhance the specific effects of treatment.

MECHANISMS FOR SPECIFIC THERAPEUTIC EFFECTS

Osteopathic management, with osteopathic manipulative treatment as the centrepiece of management, is purported to be effective for a variety of musculoskeletal and non-

musculoskeletal conditions, and there is emerging evidence to support this [3, 4, 183]. This article has focussed on the effects of treatment and associated mechanisms that relate to the treatment of somatic pain and movement disorders, either restricted passive or active movement or poorly controlled movement. The treatment of non-musculoskeletal conditions with manual therapy is contentious because of the lack of supporting evidence, but there is a growing body of clinical studies that appear to support the management of certain non-musculoskeletal conditions [5, 183-188]. However, it is not the intention of this article to review the effectiveness or mechanisms for the treatment of non-musculoskeletal systemic conditions.

Pain

Although larger trials are required to confirm the effect of osteopathic treatment, evidence suggests an improvement in pain and disability for people with low back and neck pain [3, 4], the two most commonly treated conditions in osteopathic practice [1, 2]. The hypoalgesic effects of a variety of manual techniques, such as spinal manipulation, joint mobilisation, and massage, have been demonstrated to immediately reduce pain and pressure pain sensitivity [104-107] although the longevity of these responses have not been explored. Even touch alone reduces pain [189, 190], and c-tactile afferents, which respond optimally to gentle touch, have been proposed to play a significant role in the efficacy of manual therapies [191]. Manual therapy directed at specific regions appears to produce widespread hypoalgesia, implying that the response is not segmental or local [105].

The mechanisms responsible for improvements in pain are likely to differ from person to person and involve a combination of short-term biological mechanisms that produce tissue hypoalgesia and longer-term neurological mechanisms that allow the CNS to desensitise the stimuli and psychological mechanisms that promote confidence in movement without pain. In acute pain, there will be a greater emphasis on the tissue source of nociception, but

neurological and psychosocial factors are still important (Figure 2). The biological mechanisms, such as neurological pain inhibition and clearance of tissue pro-inflammatory compounds, likely produce only small temporary changes, but the reduction in pain sensitivity may help reduce fear and protective guarding and, in conjunction with cognitive reassurance and practitioner guidance for movement, provide the confidence to move in a normal manner without fear of pain. Movement therapy approaches that use cognitive reassurance and target the beliefs, fears, and associated behaviours to encourage function have previously been proposed [192] and are reported to achieve better outcomes than manual therapy alone [193].

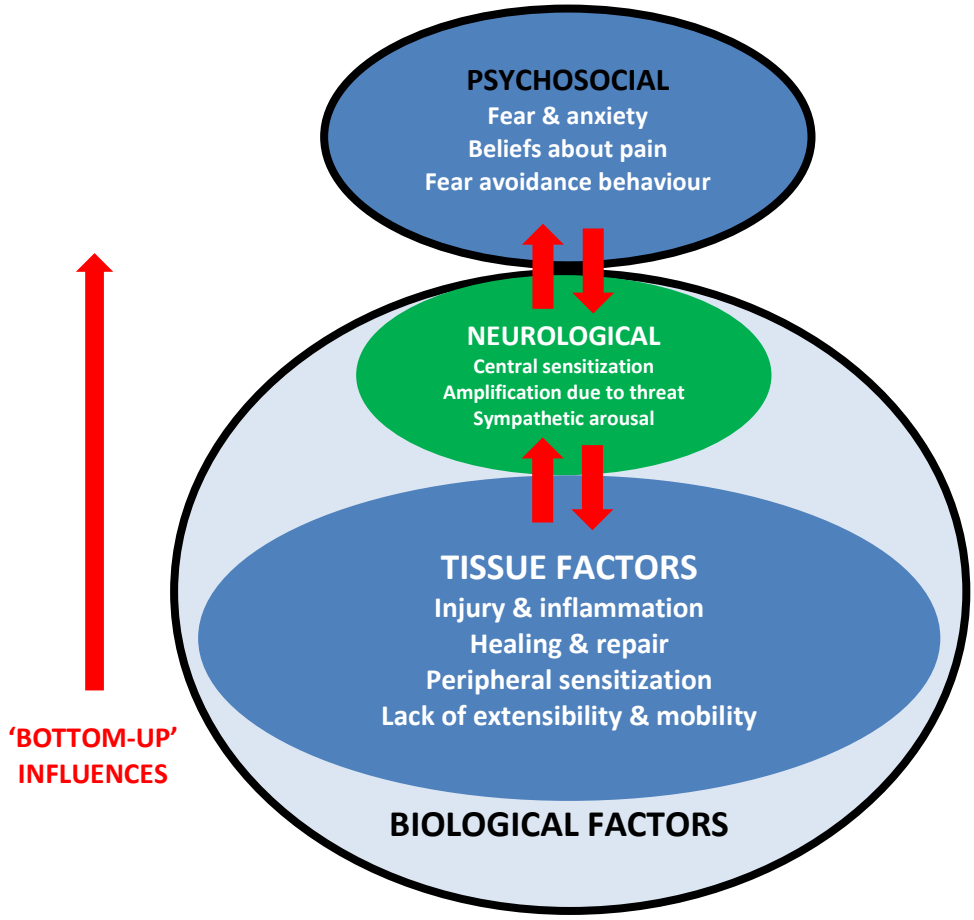

Figure 2. Psychosocial and biological factors in acute somatic pain. Figure illustrates the likely increased influence of tissue factors in acute nociceptive pain.

In chronic pain, a tissue basis for nociception is unlikely, and treatments should emphasise psychosocial interventions (Figure 3) [19]. By identifying 'yellow flag' signs, correcting inappropriate beliefs and behaviours [171, 172], and providing cognitive reassurance [176] and education about pain [178], practitioners can reduce fear, anxiety, and disability associated with pain [6].

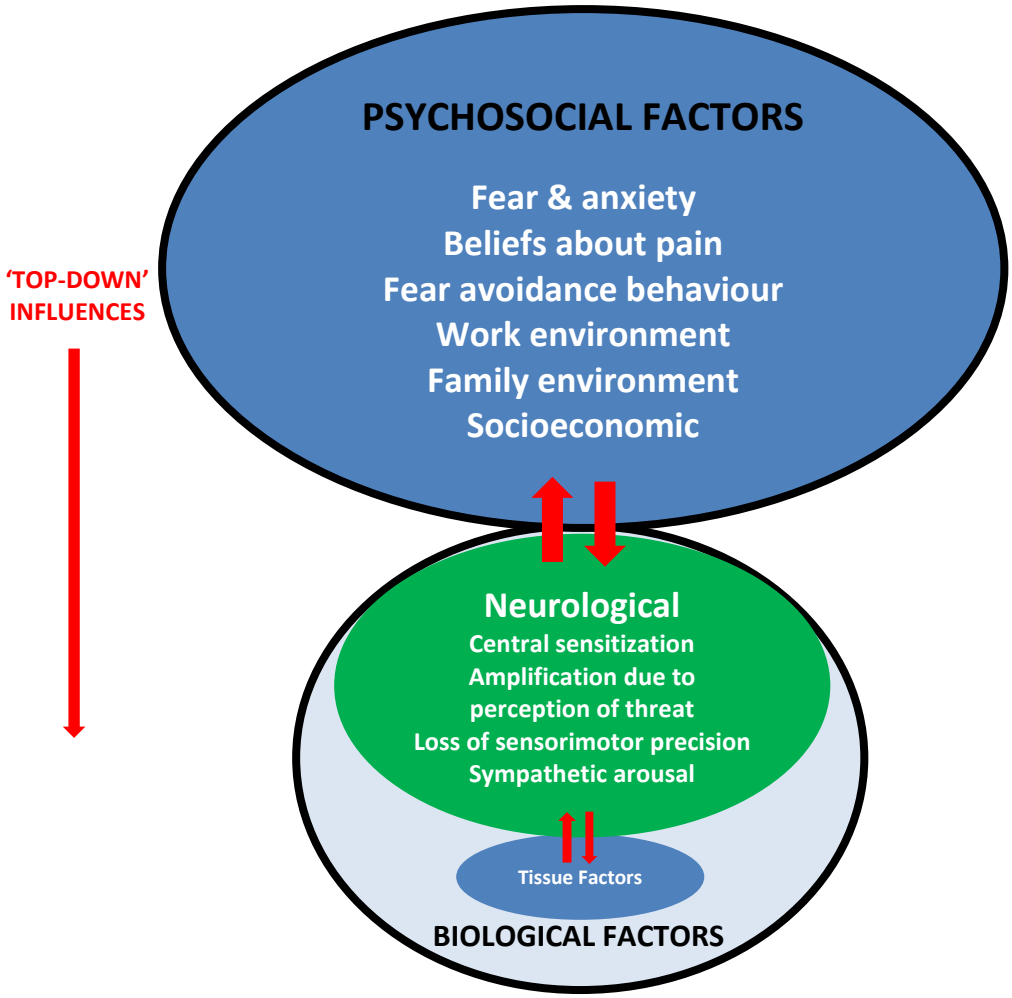

Figure 3. Psychosocial and biological factors in chronic somatic pain. Figure illustrates the likely increased influence of neurological and psychosocial factors.

Function

Osteopathic treatment has been reported to improve pain and disability [3, 4], and manual techniques have been reported to produce immediate increases in range of motion in the cervical [24-28], thoracic [194], and lumbar regions [29]. However, these increases in motion have been demonstrated only in the short term, and there is little evidence of long-term change. The mechanisms for increases in range of motion are largely speculative.

Joint cavitation and the ensuing decreased resistance to joint separation after spinal manipulation is likely responsible for increased joint motion in the short term [36, 37]. Other speculative biological mechanisms include reduction of extrapped synovial folds [37, 40] and stretch and lengthening of joint adhesions and capsular ligaments. Stretch of myofascial tissue may also produce greater muscle extensibility and joint range, but the mechanism likely involves neurological pain inhibition because studies have demonstrated a change in stretch tolerance rather than a change in tissue property [30-32].

Disability and impaired movement may be related to fear avoidance and guarding behaviour in reaction to pain [192], and the short-term biological changes in pain sensitivity and increased joint movement may provide initial movement gains, allowing for reduction of fear and improved confidence in movement with supporting cognitive reassurance for long-term improvement.

Osteopathic treatment, including manual therapy and motor control exercises, may assist sensorimotor integration and motor control, but the evidence is experimental and so this benefit is mostly speculative at present. Chronic pain affects sensorimotor processing [14, 18] and disturbs proprioception and motor control [135-137, 140-146]. Manual therapy is reported to affect sensory processing in the CNS [114-116] and produce improvements in proprioception and motor control [147-151], presumably from ‘bottom-up’ changes in

afferent feedback from the manual intervention, but the clinical relevance is still to be determined.

A reduction in pain and disability will strongly improve an individual's quality of life, and this reduction in pain may explain anecdotal reports of improved health following osteopathic treatment. However, there may be additional mechanisms—still largely speculative—that potentially enhance general health. Based on animals models, lymphatic pump techniques increased lymphatic flow [92] and augmented the immune response [93-96], and this approach potentially could have clinical relevance. Some manual approaches produce a strong parasympathetic effect [159-161], which may be clinically relevant for people who are chronically stressed and anxious.

Osteopaths encourage and promote activity and exercise and adopt stress relieving habits, which will likely have a strong influence on general health and risk factors of many lifestyle diseases. Reassurance and encouragement to be active will further encourage the person to be more active, leading to better health outcomes and a more positive outlook [195].

CONCLUSION

The biological and psychological mechanisms most likely responsible for therapeutic effect in osteopathic treatment have been discussed. Patient complaints are typically complex and multifactorial, involving a blend of biological and psychosocial factors, and treatment should address these biological and psychological factors. The evidence for mechanisms affecting long-term biomechanical and tissue changes is weak but establishes a plausible rationale for short-term changes in movement, flexibility, posture, and fluid drainage. The neurophysiological pain modulation effects of manual therapy are well established but are technique non-specific. Further, emerging evidence suggests changes to sensory and motor

processing follow manual therapy, and a general parasympathetic response follows gentle techniques directed to the neck and head. Psychosocial factors are important in chronic pain, and osteopaths can have a strong positive influence by carefully choosing their language and key messages to provide reassurance, empowerment, and positive context for people seeking treatment.

Finally, osteopaths must recognise the difference in the processes of acute and chronic pain and understand that chronic pain may not have a tissue basis. Part 2 of this article will explore the clinical approaches that arise from an understanding of the likely factors and therapeutic mechanisms involved in pain and manual therapy. More specifically, it will explore the identification of the primary processes of pain, relevant psychosocial factors, and the power of communication and language and how it can provide a positive context for patient empowerment and optimal treatment outcomes.

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