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Perspectives on tissue adaptation related to allostatic load: Scoping review and integrative hypothesis with a focus on osteopathic palpation



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ABSTRACT

Introduction: Osteopathic care may support an individual's adaptive capacity, including allostatic regulation and tissue changes in both health and disease. The palpatory findings which osteopaths claim are related to tissue changes may be linked to allostatic load. However, this putative link has not been formally investigated.

Methods: We conducted a scoping review to critically appraise the relevant literature on the relationship between allostatic processes and tissue alterations. This review evaluates the use and relevance of palpatory findings in osteopathic care. We searched on PubMed, EMBASE, Cochrane library for research exploring the links between tissue adaptation, allostasis and osteopathic palpatory findings (OPF).

Results: Recent studies provide insights into the role of allostatic regulation on body systems' responses related to tissue alterations. These results provide new insights into the relevance of OPF to clinical practice.

Discussion: We build upon the findings of our review to propose a putative model for OPF in clinical practice.

Conclusion: Although the clinical phenomena associated with OPF may be biologically plausible, it lacks the necessary underpinning research evidence. Arguably, the classical focus on the diagnosis of palpable tissue changes fails to integrate biological, social and neuropsychological aspects such as stress responses. Tissue alterations related to stress and allostatic load markers have been less studied. Tissue changes involved in the adaptive process may be useful to practitioners in the field of manual therapy, particularly in osteopathy. We propose that OPF are one of the multidimensional aspects that may inform osteopathic decision-making. However, they should be considered within a biopsychosocial perspective and taking into account concepts of allostatic load and regulation.

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1. Introduction

Health is regarded as the ability to maintain the functionality of physiological systems through adaptation (McEwen and Wingfield,

2003). Humans could maintain and develop their health (i.e., salutogenesis (Antonovsky, 1996)), even under difficult external circumstances through homeostatic-allostatic responses (McEwen and Wingfield, 2010). Homeostasis is the stability of physiological systems and is essential for life - it regulates body temperature, pH, glucose levels, and oxygen tension (McEwen and Wingfield, 2003). Allostasis is the process of achieving homeostasis through physiological or behavioural change.

Allostasis primary mediators include the hypothalamic-

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pituitary-adrenal axis (HPA), catecholamines and cytokines (McEwen and Wingfield, 2003). The physiological and behavioural changes associated with changing physical and social environments are defined as an allostatic state. An allostatic state leads to an imbalance of primary mediators, and its cumulative effect leads to an allostatic load. Allostatic load exceeds the individual's capacity to cope with the adaptive requirements. It leads to secondary outcomes (e.g., pain) and increased risk for disease - the prolonged release of allostasis primary mediators promotes tissue alterations and added to other secondary outcomes could contribute to the development of disease (McEwen and Wingfield, 2010). To date, these issues have been primarily studied from a pathophysiological standpoint, and lack application to many clinical settings (Fava et al., 2010). Notwithstanding this, several features that have been described in recent research provide the basis for the assessment of salutogenesis and allostatic load in clinical practice (Fava et al., 2010; Keil et al., 2017; Länsimies et al., 2017). Arguably, these research findings provide the basis for a critical discussion on the relevance of assessing stress in osteopathic clinical practice.

Osteopathic manipulative treatment includes a wide range of manual therapy techniques that are typically used to optimise function and reduce pain (Fryer, 2017a). Osteopaths commonly treat people presenting with musculoskeletal related pain and other associated symptoms, migraines and other forms of cranio-facial pain, and provide treatment that promotes general health (Fryer, 2017b; Tassorelli et al., 2017). Some somatic pain conditions may be explained by a maladaptive feedforward allostatic cascade model (Borsook et al., 2012). Allostatic overload precipitates the development of persistent pain due to unpredictable stress. Toxic stress levels lead to a vicious circle of “feedforward” maladaptive responses such as inflammation, brain damage and increased vulnerability to persistent pain (Abdallah and Geha, 2017). Persistent pain and chronic dysregulation of physiological systems contribute to allostatic overload in the body and brain (Abdallah and Geha, 2017). A critical evaluation of the mechanisms responsible for pain conditions such as migraine within an allostatic load model provides opportunities for the development of alternative forms of treatments (Borsook et al., 2012). Osteopaths should consider integrating stress-related psychosocial and biological in individuals presenting with persistent physical symptoms. Historically, osteopathy was utilised in the field of neuro-psychiatric at the Still-Hildrett Sanatorium in the early years of the 20th Century (Ching, 2014).

According to preliminary research findings, osteopathy may play a critical role in the care of patients suffering from chronic stress - osteopathic treatment can modulate stress and allostasis related physiological and psychological markers (Fornari et al., 2017; Emmet et al., 2018). It can be argued that osteopathy should evolve from a system of diagnosis and treatment primarily focused on the management of musculoskeletal ailments (Pettman, 2007) to a more in-depth patient-centred approach (Thomson et al., 2013). Various aspects of the biopsychosocial model and allostasis-related biomarkers and psychological markers are now considered central to osteopathic clinical practice (Fryer, 2017a, 2017b; Abbey and Nanke, 2013; Carnes et al., 2017; O'Sullivan et al., 2018; Sciomachen et al., 2018). However, in the International Statistical Classification of Diseases and Related Health Problems 10th Revision, in the Procedure Coding System section, osteopathy is still considered as a manual treatment with the aim to treat somatic dysfunction (SD) and related disorders (Barta, 2014).

The diagnosis of SD is primarily based on palpation. Notwithstanding this, the validity and reliability of palpation itself, and the role of the osteopathic palpatory findings (OPF) in the osteopathic decision-making process is still uncertain and debatable (Fryer, 2016). In particular, the debate on the validity and reliability of

palpation in osteopathy has been intense over the last years. Typically, osteopaths are confronted with overwhelming evidence of poor reliability for the use of palpation in the diagnosis of tissue alterations, as well as with a lack of research concerning practical relevance of fascial patterns (FP) and SD (Fryer, 2016; Wilke et al., 2016; Degenhardt et al., 2010). In a recent perspective paper (Fryer, 2016), SD has not been presented as a single clinical entity, but as a consequence of numerous neurological and tissue factors. Palpation alone cannot differentiate the underlying causes of the clinical signs of SD. The clinical signs of SD should be interpreted in a step-by-step decision-making process considering the context of the case history, injury, chronicity, and evidence of sensitization (Fryer, 2016). Arguably, the diagnostic reasoning requires a progressive, reflective and evidence-informed clinical decision-making process 22. We hypothesise that there is a relationship between OPF and allostasis.

This scoping review aims to critically appraise the relevant literature on the relationship between allostatic processes and tissue alterations. This review evaluates the use and relevance of palpatory findings in osteopathic care. We selected a scoping review model following a structured and rigorous procedure to describe the extent and nature of the research in a given area. This review can be used to determine where the literature is mature enough for a systematic review, to ascertain what questions the field is focusing on, and to identify knowledge gaps that can be useful in setting research priorities.

2. Methods

Review. We followed a scoping review methodology, as described by Levac and co-workers (Levac et al., 2010). We adhered to the following steps: (1) identify the research questions; (2) identify the relevant studies; (3) select the studies; and (4) collate, summarize, and report the results. We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) Checklist and explanations to report our findings (Tricco et al., 2018).

2.1. Identifying the research questions

This scoping review explored the nature and extent of published literature that described the process of tissue adaptation concerning allostatic load.

2.2. Identifying the relevant studies

2.2.1. Search strategy

We searched databases, including MEDLINE, Embase and the Cochrane Library (Table 1). We developed several research strings using the following keywords: stress, osteopathic manipulative treatment, osteopathic manipulative therapy, fascia, manual therapy, allostasis, tissue, biomechanical adaptation, tissue adaptation. No search filters were applied to avoid missing relevant studies. The search strategy included reviews, clinical trials, and observational studies. No limit of population and study outcome were applied.

2.3. Select studies

After an initial screening and deletion of irrelevant studies, we selected 22 studies for the analysis (Fig. 1). In order to draw up the review, we developed the main theme. Articles were screened for inclusion, and those not written in English were excluded. A total of 22 full articles were reviewed under theme 1: Process of tissue adaptation concerning allostatic load.

Table 1
Literature research.

Medline research strategy	((("Allostasis"[Mesh]) AND "Stress, Physiological"[Mesh]) AND "Adaptation, Physiological"[Mesh]) OR "Adaptation, Biological"[Mesh] ("Osteopathic Medicine"[Mesh]) OR "Osteopathic Medicine/diagnosis"[Mesh]) AND "Palpation"[Mesh]
Keywords	stress, osteopathic manipulative treatment, osteopathic manipulative therapy, fascia, manual therapy, allostasis, tissue, biomechanical adaptation, tissue adaptation.
Theme	Tissue adaptation process related to allostatic load.
Selected papers	Alameddine, 2012 Calsius et al., 2016 Fede et al., 2016 Kleckner et al., 2017 Langevin et al., 2011 Liptan, 2010 Malemud, 2006 Masi and Hannon, 2008 Masi et al., 2010 McEwen, 2003 McEwen, 2015 McEwen and Wingfield, 2003 McEwen and Wingfield, 2010 McPartland, 2008 Mueller and Maluf, 2002 Oken et al., 2015 Pavan et al., 2014 Picard et al., 2014 Schleip et al., 2019 Sculf, 2017 Sueki et al., 2013 Vanitallie, 2002

2.4. Collation, summarizing, and reporting results

All authors collectively discussed the charted data to identify trends, breadth, and gaps in the literature. The results are summarized both quantitatively and qualitatively. The list of journals is also reported.

Integrative hypothesis. Based on the results of the review, the authors propose a revised model concerning the role and relevance of palpatory findings in osteopathic clinical practice. In order to better understand the relationships between tissue changes and allostasis as well as their role in the decision-making process, reference lists from relevant review articles were also searched. Once additional relevant articles were identified, we did not perform a formal quality assessment; however, we critically appraise the relevance of the topic for this study. Studies were included in more than one category where appropriate.

3. Results

3.1. Process of tissue adaptation concerning allostatic load

The cumulative strain on the body produced by repeated stressor exposure can sensitize physiological responses and facilitate the development of stress-related disorders (Vanitallie, 2002). Healthy functioning requires continual adjustments to the internal physiological milieu, i.e., allostasis (McEwen, 2003). Allostatic load reflects the cumulative effects of individual stressful experiences (McEwen and Wingfield, 2003). Personal resilience could influence an individual's ability to adapt to a perturbation; also increasing the likelihood and speed of returning to the baseline state following a stressor (McEwen and Wingfield, 2003; Oken et al., 2015). When the cost of chronic exposure to self-regulation responses exceeds the coping resources of an individual, allostatic overload ensues (McEwen and Wingfield, 2003).

Adaptive processes are mediated by the brain interoceptive and intrinsic connectivity networks involved in attention and sensitivity to internal and external sensations and emotions (Sculf, 2017; Kleckner et al., 2017). The HPA and sympathoadrenal system

(Vanitallie, 2002) also implement them. Through homeostatic-allostatic responses (McEwen and Wingfield, 2010) of various systems in the body, the individual undertakes the adaptive response, facing LAS or GAS (McEwen and Wingfield, 2010). Allostasis is responsible for the regulation and integration of biopsychosocial, neurophysiological, somatovisceral, and musculoskeletal responses (Sueki et al., 2013). Allostatic load is associated with an increase in allostatic biomarkers (McEwen, 2015).

Moreover, neural receptors involved in the stress processes are associated with the immune system as a part of endocannabinoid system (Fede et al., 2016) and can modulate fascial alterations and inflammation (McPartland, 2008). The allostatic load can affect the endocrine, circulatory, respiratory, metabolic, gastrointestinal and immune systems and lead to biomechanical alterations in the connective tissue turnover (McEwen, 2003). These processes are coordinated by matrix metalloproteinases and fibroblasts, that are critical for maintaining extracellular matrix and tissue allostasis (Malemud, 2006; Alameddine, 2012).

Tissue homeostasis under stress requires fibroblasts to actively remodel their internal contractile and tension structures to adapt to augmented force and achieve connective tissue relaxation (Alameddine, 2012). Cellular inability to affect such remodelling interrupts this dynamic interplay and manifests as a strain: unresolved tension and stiffened tissue (Alameddine, 2012).

Fibroblasts respond to strain by modifying the shape and alignment of the fascial matrix and by secreting inflammatory cytokines (Malemud, 2006). When mechanical stress continues, the fascia becomes disorganized as a result of an excessive amount of collagen and extracellular matrix being deposited. This histological modification leads to increased fibrosis and fascial adhesions (Mueller and Maluf, 2002). Changes in the relative level of physical stress cause a predictable response in all biological tissues. Physical stress is the force, or load, acting on a given area of tissue. The physical stress theory (Mueller and Maluf, 2002) proposes that tissues accommodate physical stresses by altering their structure and composition to meet the mechanical demands of routine loading. Mechanical stress associated with an overload of self-regulatory systems can be responsible for strain in the tissues

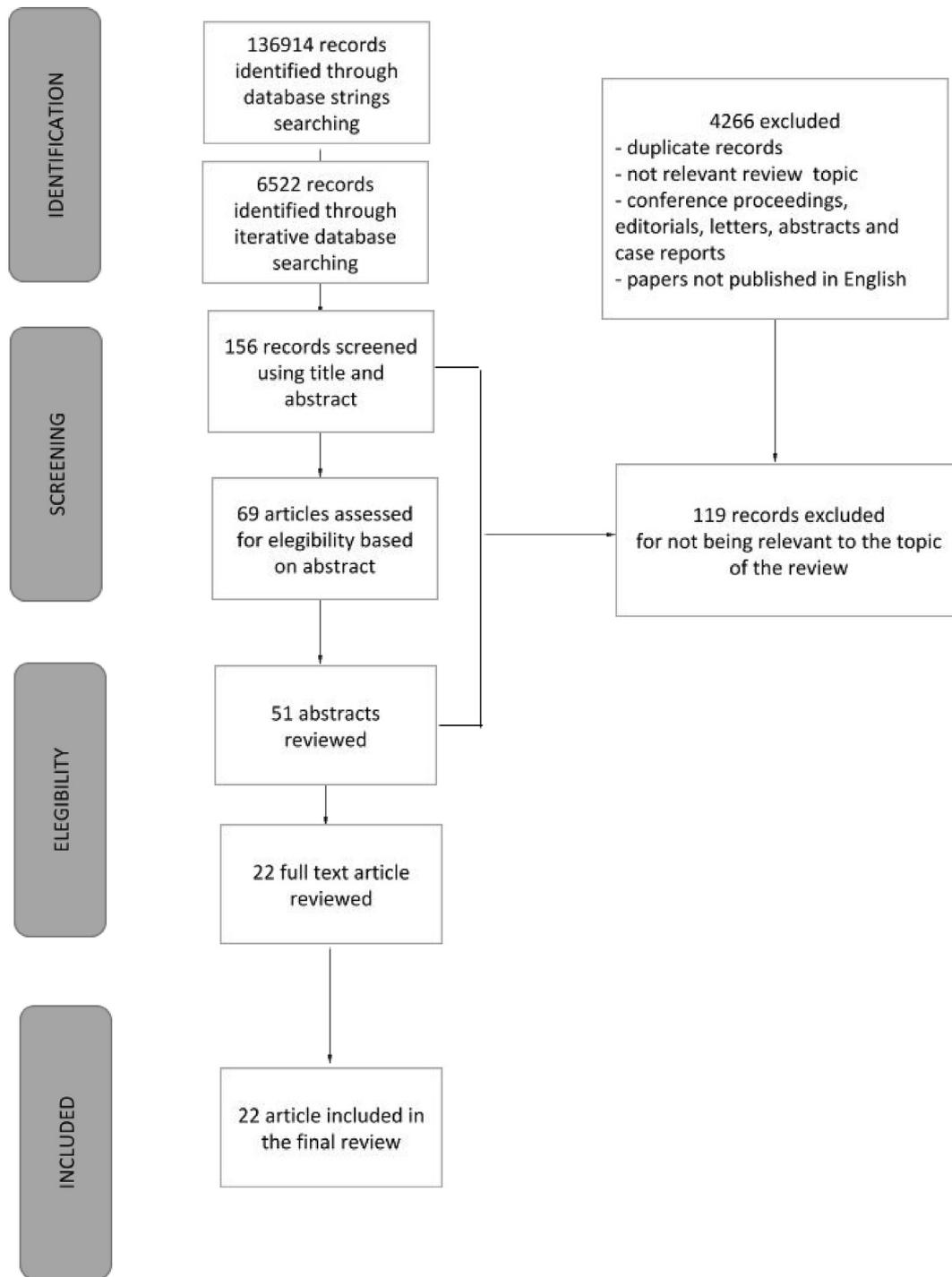


Fig. 1. Selection process.

(Masi and Hannon, 2008) (manifested by plastic or elastic deformation). Ageing and metabolic disease, as well as trauma or surgery, could alter the fibrous layers of fasciae, leading to fascial fibrosis (Pavan et al., 2014). This plastic deformation is difficult to modify: only early-guided mobilization enables true healing of the deep fasciae in order to avoid the formation of fibrosis. Incorrect lifestyle habits, such as diet, exercise, and overuse syndromes can modify the viscosity of loose connective tissue within the fascia, causing densification, a reversible strain that is possible to modify (Pavan et al., 2014). Chronic densification alters the gliding action

between adjacent fibrous layers, also affecting collagen fibre deposition, even at a site distant from the first site of densification (Langevin et al., 2011). The reversible elastic deformations beside human myofascial human resting tone (HRMT), are related to different tissue assessable properties such as stiffness, viscoelasticity, thixotropy, the resonant frequency of the vibrating body (Masi and Hannon, 2008).

The viscoelastic property that allows dissipation and transmission of forces and informations (Masi et al., 2010) provides stabilizing support to maintain adequate adaptive tissue capacity.

The fascia is also an interconnected tension network that adapts its fibrous structure and density according to local or generalized tension requirements. The anatomical network spontaneously tends to maintain mechanical balances through a pre-activation state. Tissue alterations related to decreases or excesses of local or general HRMT can favour chronic diseases (Masi and Hannon, 2008; Masi et al., 2010), systemic inflammation and brain diseases (Liptan, 2010; Picard et al., 2014). Although this tensional force of fascia can operate autonomously from muscle tone (Masi and Hannon, 2008; Masi et al., 2010), it is thought that in endured conditions it can lead up to a fascial stiffness due to its sensitivity for over-activation of the autonomic nervous system or stress (Liptan, 2010; Calsius et al., 2016). This may lead to transmission between sympathetic over tuning and myofibroblast proliferation resulting in myofascial tissue stiffness (Liptan, 2010; Calsius et al., 2016).

McEwen and Wingfield proposed that fascial system alterations could be considered as predisposition, precipitating and maintaining factors in several diseases (McEwen and Wingfield, 2003). Progressive changes of fascial stiffness might influence the motoneuronal coordination aspect involved in musculoskeletal parameters such as low back stability (Calsius et al., 2016). Stiffness changes in lumbar fasciae may influence the complex dynamics of anticipatory adjustments which play an essential role in human postural regulation (Schleip et al., 2019). Some chronic disorders develop asymptotically over a considerable time frame and are characterized by increased tissue stiffness: it is supposed a potential contribution of fascial myofibroblasts activity (Schleip et al., 2019). Minor fascial stiffness changes could be involved in the phenomenon of SD described in the osteopathic literature (Schleip et al., 2019). Manual therapists, such as osteopaths, interpret tissue changes not limited to the biomechanical system; they also consider dysfunctions as the expression of an overload of other systems and allostatic processes that, in turn, influence musculoskeletal function and clinical presentation (Schleip et al., 2019). These considerations are linked to the concept of 'regional interdependence' according to which a dysfunctional unit in a system may deliver abnormal stress to different segments in the same system or within other related systems, hence favouring the establishment of new dysfunctions elsewhere (Sueki et al., 2013). Therefore, the aberrant mechanisms initiated and maintained by the primary dysfunctional area may induce an allostatic response (Sueki et al., 2013), involving interdependent biological and psychosocial processes (Sueki et al., 2013). Hence, clinicians might consider the relationship between biopsychosocial, neurophysiological, and musculoskeletal factors when evaluating and treating patients (Sueki et al., 2013).

4. Discussion

The results of this review provide insights into the role of allostatic regulation of body systems' responses associated with tissue changes commonly diagnosed by palpation. To this end, these results may provide new insights on the relevance of palpatory findings in osteopathic clinical practice (Fig. 2.).

Clinical phenomena associated with palpatory findings may be biologically plausible, but the relationship between tissue changes and health status has not yet been established (Fryer, 2016). Moreover, the classical focus on the diagnosis of palpable tissue changes fails to integrate biological, social and neuropsychological aspects such as stress responses (Fryer, 2016). On this point, a recent review provides a critical reflection on new models of osteopathic diagnosis and care (Smith, 2019). Clinical reasoning in osteopathy needs to move away from exclusively tissue-based diagnosis. Diagnostic palpation lacks the appropriate clinical

levels of validity and reliability to be considered as central to the diagnostic process as previously proposed by authors in the field of osteopathy.

Notwithstanding these challenges, osteopaths remain highly skilled in musculoskeletal medicine and particularly in the use of touch-based interventions (Smith, 2019). Although some are waving the flag of biopsychosocial principles and advocating a hands-off approach to treatment with a and purely using a psychosocial approach (Smith, 2019), as a community of practice, osteopaths should critically to reflect on how to implement an evidence-informed approach to their clinical practice. Rather than merely following the pendulum swinging between the application of biomechanical or biopsychosocial models, osteopaths should consider the role of individualized patient care (Smith, 2019). Sampath and colleagues (Sampath et al., 2019) argued that the bridge between biomechanical and psychosocial models might lay in the integration of stress physiology, pain and inflammatory responses and processes in osteopathic clinical practice (Sampath et al., 2019). In line with other authors' viewpoint (Pelletier et al., 2018), Sampath and co-workers (Sampath et al., 2019), argue that manual therapy initiates a cascade of neurophysiological changes in various systems including the peripheral nervous system, autonomic nervous system and the endocrine system, thus influencing the hypothalamic-pituitary-adrenal axis and stress response system. Therefore, the authors propose the use of objective measurements of the allostatic load before and after an intervention to explore the role of osteopathic treatment on stress physiology, pain and inflammation (Sampath et al., 2019). Although their proposal is robust, further research to investigate, for example, the relationship between somatic dysfunction or more generally tissue changes, and allostatic load and stress responses.

We would argue that the relation between tissue changes and allostasis provides a suitable foundation for the development of new models of osteopathic care. Revised models should consider the critical role of hands-on treatment to support the patient's adaptive process - i.e., within a biopsychosocial framework. It remains vital to practitioners deploy well-developed skills of patient assessment to identify conditions requiring medical referral, and drivers behind pain and altered function in order to deliver safe and effective osteopathic care. Here we propose a model that links up allostasis, palpatory findings and adaptation. This model will enable osteopaths to understand how allostatic load-related tissue changes and patient's perception may inform their decision-making. Early publications in the field of osteopathy (Tasker, 1905), reported that practitioners gave significant importance to tissue changes within the context of self-regulation. The osteopathic lesion, now classified as somatic dysfunction, was considered as a structural change that negatively affects tissue and self-regulative systems' functionality (Tasker, 1905). Although the profession has mostly moved away from unvalidated cause-effect models of osteopathic care (Smith, 2019), some of the original concepts of self-regulation and adaptation can still have a role in modern osteopathic practice (Tasker, 1905).

4.1. OPF in clinical practice: a putative allostatic load model

Authors in the field of osteopathy have recently proposed that the evaluation of the patient's adaptive capacity plays a central role in osteopathic clinical practice (Sampath et al., 2019; Lunghi et al., 2016). Dysfunction in the body's self-regulatory systems may contribute to the development, persistence and exacerbation of physical symptoms. Different authors have proposed two-stage clinical reasoning in osteopathy (Lunghi et al., 2016; Grace et al., 2016). Firstly, by using a biomedical approach to exclude red flags, to assess baseline pain severity, pain mechanisms and

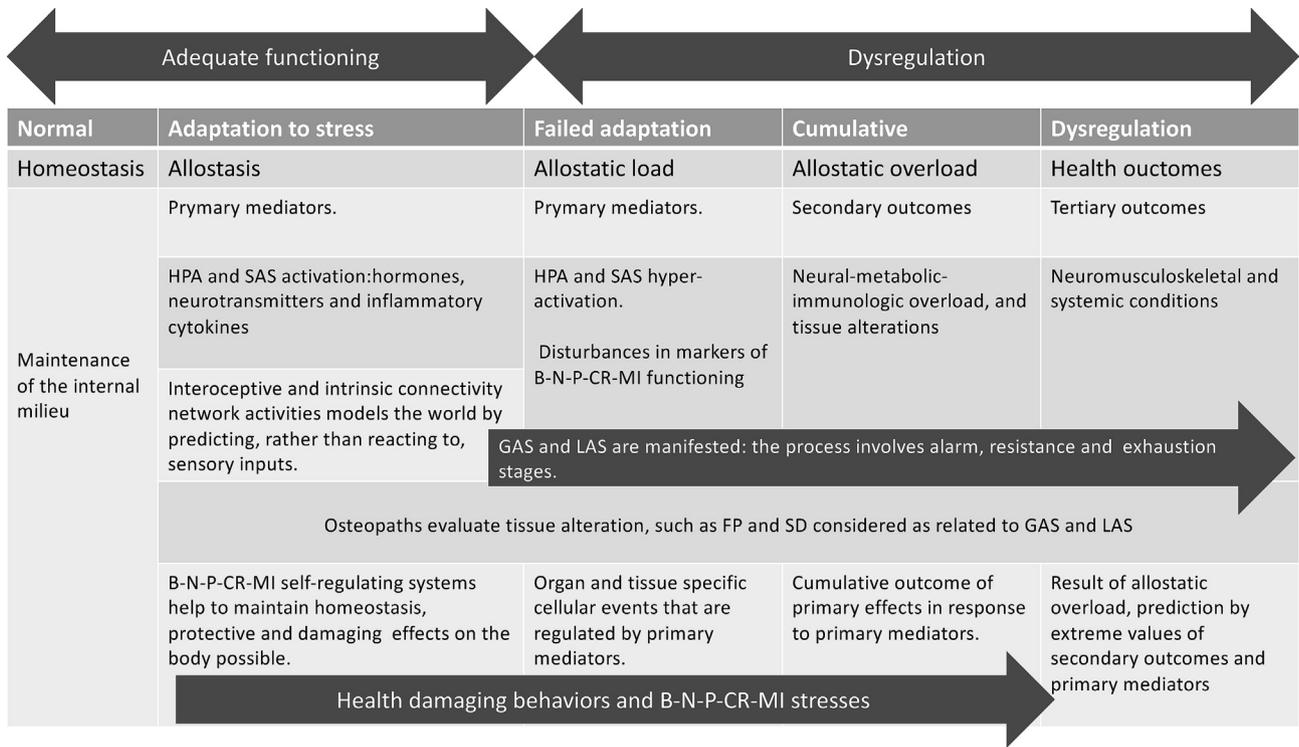


Fig. 2. Stress-regulating process and correlated tissue alterations considered in the osteopathic field. Adapted from Mauss et al. (Mauss et al., 2014).

functional outcomes. Secondly, by reasoning through the lens of the structure-function models as part of ‘osteopathic knowledge’ (Lunghi et al., 2016; Grace et al., 2016). According to several authors, clinical reasoning in osteopathy is informed by the relationship between subject and objective examination, assessment of salutogenesis (Eriksson and Lindström, 2006), biomarkers and psychological markers of allostatic load (Fava et al., 2010; McEwen, 2015), a functional examination of body systems, and osteopathic palpation (i.e., fascial FP and SD related to GAS and LAS50 (Table 2). Biopsychosocial factors such as fear-avoidance beliefs, catastrophizing, anxiety, altered mood, and bothersomeness also require attention (Fava et al., 2010). Within a biopsychosocial framework, osteopaths might use different models of osteopathic care based on the clinical presentation, their skill level, and the patient’s preferences (Lunghi et al., 2016). Moreover, they should also consider the role of different forms of touch-based treatment techniques and the specific physiological and behavioural effects on patient’s perception, tissue changes and self-regulatory systems (Lunghi et al., 2016).

4.2. OPF and osteopathic diagnosis

Rabey and colleagues (Rabey et al., 2017) argued that palpation alone, and its underlying biomechanical rationale, cannot differentiate the causes of the patient’s clinical presentation. In light of the above considerations, the integration between the palpatory assessment and patients’ perception may enable osteopaths to appraise the relevance of OPFs critically. For example, the patient’s response to pain provocation tests or enhancements in the quality of motion may inform the osteopath’s selection of treatment techniques (Lunghi et al., 2016). Incorrect communication or misunderstandings regarding the type of treatment procedure may negatively influence the individual responses to treatment (Lunghi

et al., 2016). In order to facilitate the healing process, the patient needs to give meaning to their illness experience and the healing process. The meaning itself has a therapeutic value able to transform the person’s illness experience through placebo (Ishizu and Zeki, 2011; Etzi et al., 2014). Positively valenced (pleasant) exteroceptive stimuli (e.g., touch) are likely to activate the interoceptive areas of the brain and modulate pain responses (Ishizu and Zeki, 2011; Etzi et al., 2014). Arguably, touch-based osteopathic techniques could evoke similar responses (Cerritelli et al., 2017). In contrast, negatively valenced experiences (unpleasant) may increase anxiety and pain (Ishizu and Zeki, 2011; Etzi et al., 2014). This includes negative messages that local biomechanical dysfunction is the sole driver behind chronic musculoskeletal disorders (Pelletier et al., 2018). Neural changes resulting from changes in areas of the brain involved in pain processing and psychological states contribute to the pain and altered function patients’ experience (Pelletier et al., 2018). Sensory discrimination training is associated with increased pain thresholds and improved function in patients with chronic pain. During the osteopathic diagnosis and treatment process, patients should be attentive to differences in pressure, mobility and tissue texture during treatment (Pelletier et al., 2018). The patient’s focus and motivation should be directed away from their symptoms and their avoidance coping strategies, towards the improvement of function (Pelletier et al., 2018).

Since its inception in 1874, osteopathy has favoured a person-centred approach to care. Despite this, osteopaths traditionally focused on a biomechanical model of care, including postural and structural diagnosis, that might not be related to the presenting symptoms (Smith, 2019). A biomechanically-focused model of osteopathic care can be regarded as an operator-centred approach rather than person-centred (Esteves et al., 2020). It has, therefore, been argued that it is time to support integrated models where hands-on care is adequately implemented within a person-centred

Table 2
Integration of osteopathic palpatory finding, individual adaptive ability and multidimensional aspects of patients' complaints.

Individual adaptive ability		Patient's responsiveness (Cook et al., 2015) ⁺ ⁺ write results in the three columns below	
Allostatic index* * write patient's reported results in the right column	Body systems' functional examination [°] [°] write results of the functional physical examination in the right column		
<ul style="list-style-type: none"> - Biomarker: blood pressure, metabolic parameters (glucose, insulin, lipid profiles, and waist circumference), markers of inflammation (interleukin-6, C-reactive protein, and fibrinogen), heart rate variability, sympathetic nervous system activity (12-hour urinary norepinephrine and epinephrine) and hypothalamic–pituitary–adrenal axis activity (diurnal salivary free cortisol)(McEwen, 2015); - Psychomarker: body perception questionnaire-short form(Cabrera et al., 2018), Depression, anxiety and stress scales (Keller et al., 2012), salutogenesis index (sense of coherence questionnaires) (Antonosky, 1993); - Lifemarker: i.e. Social Readjustment Rating Scale (Holmes and Rahe, 1992). 	<ul style="list-style-type: none"> - Biomechanical: postural control test (Bohannon and Tudini, 2018); - Neurologic: manual assessment tests of central sensitization (Nijs et al., 2010) and of autonomic nervous system tone (Cheshire and Goldstein, 2018); - Metabolic: gastrointestinal distress signs ; - Circulatory: examination of the amplitude of the peripheral pulses, considering its relationship with arterial stiffness (Cheshire and Goldstein, 2018); - Respiratory: manual assessment of respiratory motion (Courtney et al., 2008); - Biopsychosocial: Waddell's signs (Centeno et al., 2004); 		
Familiar symptoms		Comparable signs	Objective examination findings
Somatic Dysfunction (WHO, 2010)	Somatic Dysfunctions Regions	Segmental Dysfunctions Areas	Tissue involved T A R T Severity (1 to 4) Clinical relevance (yes/no) Selected techniques
	Head		D I C
	cervical		D I C
	thoracic		D I C
	lumbar		D I C
	sacral		D I C
	pelvic		D I C
	upper extremity		D I C
	upper extremity		D I C
	rib cage		D I C
	abdomen		D I C
Fascial Pattern (Astrud et al., 2017)	Defined according to the current version of the Terminologia Anatomica		S S S S S

framework to address the individual patient's needs adequately (Smith, 2019; Esteves et al., 2020). To this end, the osteopathic examination should be reconceptualized away, mainly, from biomechanical interpretations (Smith, 2019; Esteves et al., 2020). As Rabey and colleagues (Rabey et al., 2017) proposed, osteopathic examination findings should not be considered only in terms of how they should guide treatment, primarily from a biomechanical perspective. Osteopaths should also take into account information from the patient regarding their symptoms and wellbeing as well as from diagnostic imaging and other clinical tests, in order to make sense of intricate clinical patterns (Walton and Elliott, 2018). Information from various sources and dimensions combined with the interpretation of osteopathic palpatory findings enable clinicians to develop appropriate individualized care. Rather than considering the validity of clinical tests solely on their reliability, palpatory findings play a crucial role in informing clinical reasoning in osteopathy (Rabey et al., 2017).

4.3. OPF and their role in clinical decision-making

Different approaches to clinical decision-making have been described in osteopathy. The “biomechanical approach” focused on the evaluation of positional and movement asymmetries. It is based on the theoretical - often predetermined - relationship between anatomical areas and patient clinical presentations (Lunghi et al., 2016). A “probabilistic approach” (Childs et al., 2004) in which the operator uses clinical prediction rules to understand the value of the pathophysiological and pathognomonic data collected, using

them as moderators and decision-making modifiers. Clinical examinations and clinical signs related to maladaptation of the body regulatory systems may inform the selection of structure-function models in osteopathic care (Lunghi et al., 2016; Childs et al., 2004). A list of variables or predictors of allostatic overload associated with tissue changes may enable practitioners to implement tailored treatment interventions effectively. Another approach in use is the “method based on the patient's response”. Practitioners integrate their knowledge of biomechanics, neuroscience, and the biopsychosocial model in the diagnostic phase. Pain provocation and motion palpation tests are employed to evaluate the clinical relevance of tissue changes (Lunghi and Baroni, 2019). Clinical reasoning in osteopathy can also be based on a mixed decision-making model using hypothetico-deductive and pattern recognition strategies, depending, for example, on case difficulty or similarities to previous cases (Childs et al., 2004; Lunghi and Baroni, 2019; McIntyre et al., 2018). In the mixed decision-making model, palpatory findings are considered together with other factors to formulate a working diagnosis and a tailored treatment plan. As D'Alessandro et al. (D'Alessandro et al., 2016) argued, osteopathic manual techniques should be viewed as a vehicle to deliver touch effects, which can have a positive influence on the sense of “self”, wellbeing and body image, as well as profound calming-soothing influence on the individual. Positive effects on the “integration between interoceptive-proprioceptive-exteroceptive systems and allostasis” (Seth and Friston, 2016), can be achieved primarily if an “osteopathic adaptive approach” is considered (Esteves et al., 2020). Osteopathic care provides a privileged entry-point to the

“integration of proprioceptive-interoceptive system and allostatic pathways” (D’Alessandro et al., 2016; Ponzo et al., 2018; Tamburella et al., 2019). The use of evocative language, movement and patient feelings during palpation and osteopathic treatment, facilitates embodied self-awareness (Schleip et al., 2019). Treatment based on the empathic relationship and tissue changes aims to relieve the patient from manifestations related to the overloaded systems (Pelletier et al., 2018; Lunghi et al., 2016).

4.4. Limitations

Narrative scoping reviews take a less formal approach than systematic reviews. Nevertheless, in the present scoping review, we utilised a more rigorous design including reporting methodology (Levac et al., 2010), search terms, databases used, article selection, inclusion and exclusion criteria, and data extraction. A limitation of this study includes the low number of studies currently available. We were, therefore, unable to conduct a systematic review thus increasing the risk of using biased or poor-quality studies. Several studies selected for review are primarily based on an individual’s perspective rather than primary research. The reduced number of articles highlights the need for further research. Studies with robust methodology are recommended to obtain reliable and generalizable results. It could be the case of studies designed to achieve a validation process and hypothesis testing. Interprofessional face-to-face consensus meeting, world café (Anderson, 2011) and qualitative analysis (French et al., 2017) could represent an excellent way to identify and appraise experts’ relevant consensus statements on these topics.

5. Conclusions and perspectives

The present review critically appraised the available literature on tissue changes related to stress, allostatic load and adaptation. We suggest that described concepts are relevant to osteopathy and other forms of manual therapy. They provide practitioners with relevant knowledge regarding adaptative processes related to allostasis. In the discussion, the correlation between OPF and allostatic index in the clinical practice is presented. We propose that OPF is one of the multidimensional aspects that may inform osteopathic decision-making, but it should be considered within a biopsychosocial perspective and taking into account concepts of allostatic load and regulation. Future research is needed to develop a shared and robust framework for clinical reasoning in osteopathy.

Declaration of competing interest

Each author of the present review declared no conflict of interests.

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List of abbreviations

HPA	hypothalamic–pituitary–adrenal axis
OPF	osteopathic palpatory findings
FP	fascial patterns
SD	somatic dysfunctions
HRMT	human myofascial human resting tone
TART	tissue texture alteration, positional asymmetry, mobility restriction, and tenderness
GAS	(general adaptation syndrome)
LAS	(local adaptation syndrome)

Ethics approval and consent to participate

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Authors’ contributions

CL, GC, MT did the research and the selection process. CL, GC, MT, wrote the first draft of the manuscript. JE and FC made corrections and useful comments on the whole manuscript. All authors read, revised critically and approved the final manuscript.

Authors’ information

None.

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