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A new perspective for Somatic Dysfunction in Osteopathy: the Variability Model

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ABSTRACT

Introduction: Osteopathy uses manipulative techniques to support physiological function and adaptation. These conditions are modified by the presence of Somatic Dysfunction (SD), an altered function of the components of the body's framework system. Despite SD's widespread use in clinical practice and education, research has previously shown poor results in terms of reliability and validity.
In this theoretical article, the authors' proposal is to argue for a new clinical perspective for SD, which suggests a different palpatory assessment of its clinical signs: the "Variability Model".
Methods: A double simultaneous literature search was performed between January and March 2019 in Medline's electronic database. The first one critically analysed the clinical signs most used to detect SD. The second one informed authors' hypothesis related to movement variability assessment in the Neutral Zone (NZ).
Discussion: The Variability Model explains how the assessment of the range of motion in the NZ is essential to detect SD, its motion asymmetry and its relative restriction.
The Variability Model explains SD semeiotics which could be related to "body adaptability", thus having implications with the concept of health. Finally, this paradigm aims to establish new developments in research, especially regarding SD reliability and clinical relevance.
Conclusions: Movement variability allows to interpret SD clinical signs as an attempt by the body to maintain a healthy condition. This paradigm should be included in the future context of osteopathy which could better explain SD's pathophysiological mechanism, without ignoring the accuracy of its physical examination.

1. Introduction

An increasing number of people with neuro-musculoskeletal disorders refer to manual and manipulative therapies such as osteopathy, chiropractic therapy, and physiotherapy for their care (AOA, 2018; WFC, 2019; IFOMPT, 2019). All these professions share the use of hands as a diagnostic and therapeutic tool.

Osteopathy emphasises the functional integrity of the body using various manipulative techniques to improve physiological function and support homeostasis altered by the so-called Somatic Dysfunction (SD) (WHO, 2010; ICD, 2018). SD is defined as an 'impaired or altered function of related components of the body framework system: skeletal, arthrodial, and myofascial structures, and their related vascular, lymphatic, and neural elements.' (AACOM, 2017).

Several authors have tried to explain SD pathophysiology; Korr et al. (1947, 1962, 1975) and Denslow et al. (1941, 1947) suggested that myofascial disorders can produce abnormal afferents to the spinal cord, 'facilitating' interneural thresholds and producing exaggerated sensory, motor, and sympathetic responses. Van Buskirk (1990) attributed a key role to nociception, thus producing abnormal output and related tissue changes. Fryer (1999, 2016) explained how strains and articular degenerative changes could lead to nociceptor activation, producing vasodilation and neurogenic inflammation. Recently, alterations in the gliding-sliding properties of tissues have been recognised as a key element in SD, as they can cause thickening and densification of the fascial system, resulting in an alteration of their function (Chaitow, 2014).

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SD is claimed to be detected by osteopaths using four characteristic clinical signs: tissue Texture abnormalities, positional Asymmetry, Restricted range of motion and Tenderness which are summarised by the acronym TART (Kappler et al., 1997). These clinical signs are driven by tissue, neuronal, vascular factors, subsequent traumatic tissue changes, nociceptive and interoceptive functions, and other aspects such as sensitisation and inflammation (Fryer, 2016).

Although many different paradigms have been hypothesised to describe the complexity of this mechanism, TART remains the most used for SD diagnosis (Channell, 2016; Snider et al., 2016).

Since now, SD is still a basic concept in osteopathic practice. Despite its crucial role, its clinical relevance is questionable due to its unclear pathophysiology and poor reliability (Fryer, 2016). Furthermore, the relationship between the state of health and its presence/absence is still not demonstrated (Moran, 2016).

Several studies have investigated SD assessment reliability; a recent systematic review (Basile et al., 2017) explained how the reliability levels of osteopathic tests were heterogeneous, with K values being far from clinical significance. The authors concluded that new assessment strategies could improve palpation test reliability.

In this theoretical article, the authors' proposal is to argue a different palpatory assessment to identify SD. The new paradigm, defined as “Variability Model”, is based on recent evidence and the authors' clinical expertise.

2. Methods

An expert working group, with at least 10,000 hours of professional practice in the fields of education, scientific research and clinical practice in osteopathy, developed the theoretical framework for understanding the research question. It came from a brainstorm based on clinical observation and using the best available evidence.

The Variability Model construction was based on assumption that inter-rater reliability may improve examining the initial resistance-free movement because it can enhance tactile perception (Petty et al., 2002; Nyberg and Smith, 2013). Also, the movement variability can have a functional role in helping individuals adapt to ever-changing constraints imposed on them by environmental, anatomical, physiological and pathological changes (Davids et al., 2003; Stergiou et al., 2006).

In order to highlight current evidence related to SD assessment and to analyse some possible critical aspects, and to speculate the Variability Model the authors carried out a review of the literature.

A double simultaneous literature search was performed between January and March 2019 in Medline's electronic database. The first one critically analysed the TART clinical signs including the following search terms in order to identify relevant studies in the database from the past 20 years: “somatic dysfunction”, “osteopathy”, “diagnosis”, “evaluation”, “assessment”, “physical examination”, “tissue texture”, “abnormal”, “abnormality”, “motion”, “range of motion”, “restriction”, “position”, “landmark”, “asymmetry”, “tenderness”, “pain”, “painful”, “sensitivity”, “sensitisation”, “palpation”, “reliability”, “reproducibility”, “validity”. To be included in this paper's section, studies had to meet the following inclusion criteria: investigation into palpatory evaluation resulting from any form of manual and manipulative therapies, with special attention to osteopathy and written in the English language only. Studies were excluded if they were not relevant to palpation in the physical examination or not related to functional and motion evaluation. The authors followed the selection process independently; validity and quality assessment were not performed in order to not impose any form of restriction to the review. The study selection process comprised two phases. During the first phase, the authors reviewed the abstracts of the studies. Those that failed to meet the eligibility criteria on the basis of the content of their abstracts were excluded during this stage. During the second phase of the selection process, the eligibility criteria were applied to the full-text versions of the studies using the same screening method used for the abstracts.

The second literature search aimed to analyse authors' new hypothesis related to Neutral Zone palpation including the following search terms: “neutral zone”, “neutral position”, “rest position”, “elastic zone”, “range of motion”, “end-feel”, “stiffness”, “pain free”, “palpation”, “manual examination”, “manual assessment”, “physical examination”. Articles eligibility and selection process were the same for the critical analysis of TART clinical signs.

3. TART critical analysis

3.1. Texture

Osteopathic practitioners consider Tissue Texture (TT) abnormalities as a diagnostic indicator of SD (Greenman, 1996; Kuchera et al., 1997) even if the nature of this variation remains unclear and largely theoretical (Fryer et al 2004a, 2004b).

TT alterations could be the expression of a musculoskeletal disorder, such as increased Electromyographic (EMG) activity of paraspinal muscles detected as ‘abnormal’ by palpation, in Low Back Pain (LBP); however, it is unclear if this abnormal EMG activity is a cause, a consequence, or even an adaptation to the pathophysiological process (Fryer et al 2004a, 2004b). Recently, paraspinal EMG activity and palpation were investigated (Fryer et al., 2010) and no association was found, suggesting that TT variation is probably mediated by other aspects (e.g., inflammatory processes or fluid congestion). In addition, there is a lack of evidence concerning the connection between altered TT and its clinical relevance (e.g., palpation of myofascial trigger points in non-specific LBP) (Njoo and Van der Does, 1994). Finally, other studies (Fryer et al., 2005a) showed no relation between abnormal TT palpation and the corresponding size of the examined tissues where ultrasound proved that spinal muscles classified through palpation as ‘different’ were, de facto, of similar dimension.

Therefore reliability and validity of TT palpation is poor and does not explain the complexity of this clinical sign.

3.2. Asymmetry and restriction of motion

Asymmetry and restriction of motion are defined as ‘quantitative and qualitative alterations of motion range’, ‘range of motion changes’, or ‘range of motion abnormality’ (DiGiovanna et al., 2005; Gibbons and Tehan, 2008; Parsons and Marcer, 2008).

Asymmetry in SD has been studied in relation to skeletal position and movement in different body areas, with a specific focus on differences between the two sides (Cibulka et al., 1998; Spring et al., 2001; Degenhardt et al., 2005, 2010; Fryer et al., 2005b; Fryer, 2006; Holmgren and Waling, 2007; Kmita and Lucas, 2008; Rajendran and Gallagher, 2011; Bengaard and Bogue, 2012; Sutton et al., 2013).

However, asymmetries in the human body are possible (Badii et al., 2003; Krawiec et al., 2003; Boulay et al., 2006; Auerbach and Ruff, 2006; Preece et al., 2008; Brink et al., 2017) for many reasons related to genetic (Auerbach and Raxter, 2008), physical development (Kanchan et al., 2007), traumatic (Thevenot et al., 2010), or biomechanical (Hart et al., 2016) causes. In the majority of cases, there is no specific dysfunctional or pathological meaning (Seminati et al., 2013). In addition, skeletal asymmetry can lead to asymmetries in mobility and influence related clinical measurements (Al-Eisa et al., 2006a, 2006b).

Concerning motion restriction, there is no significant evidence

regarding its reproducibility during the assessment. Degenhardt et al., (2005) highlighted that reliability levels of spinal mobility tests are not clinically acceptable, even if consensus training could improve it.

Other authors (Seffinger et al., 2004) reviewed the literature finding no satisfying inter-rater reproducibility, especially in landmark palpation and in motion testing. Similarly, Stochkendahl et al. (2006) pointed out that static and dynamic palpation of the spine is not reliable, sometimes contradictory.

3.3. Tenderness

Palpable signs of SD can be detected in both symptomatic and asymptomatic subjects (Fryer et al., 2004c). Some theories assume that the presence of SD in asymptomatic individuals could generate biomechanical and neurological sequences leading to pain, or other symptoms referred by the patients (Korr, 1954; Patterson and Wurster, 2011).

Several authors rejected the inclusion of 'tenderness' as a specific sign for SD diagnosis; others have preferred to convert it to the term 'Sensitivity' (AACOM, 2017).

As a consequence of the development of pain-related sciences, the innovative concept of Central Sensitisation (CS) has probably integrated and partially replaced the hypothesis of authors such as Korr, Denslow, and Van Buskirk (D'Alessandro et al., 2016).

Sensitisation develops as a result of nociceptive inputs, which generate a prolonged increase in excitability and synaptic transmission of the neurons of the major central pathways (Woolf, 2011). This process involves functional and neuroplastic re-adaptations in several centres of the Central Nervous System (CNS), thus producing a prolonged activation of the pain transmission pathways (Latremoliere and Woolf, 2009).

The clinical features of the CS phenomenon are hyperalgesia (a normally painful stimulus which produces an exaggerated response) and allodynia (a normally non-painful stimulus which produces pain) (Nijs et al., 2010).

The exaggerated response to a stimulus could trigger neurogenic inflammation, thus triggering tissue disorders, resulting in pain originating from the CNS. Therefore, CS would clinically explain the concept of 'tenderness', even when a primary tissue lesion may no longer exist.

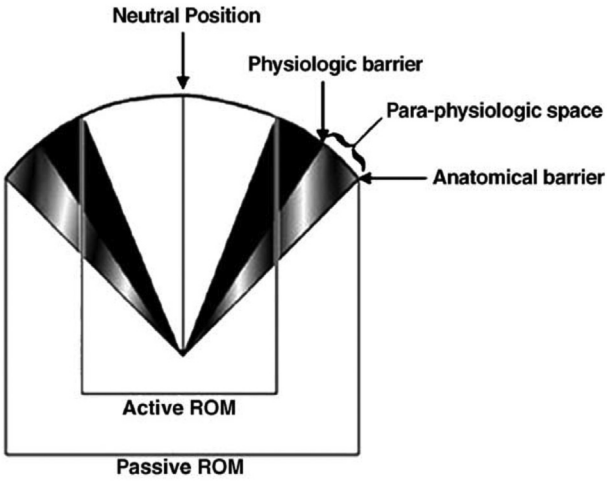

Fig. 1. Evans and Breen (2006), use with permission. ROM (active, passive, total) and its barriers (physiological, anatomical). NP: the position in which the overall osteo-ligamentous stresses and the muscular efforts to hold the posture are minimal. End-Feel: quality of motion when stressed against the paraphysiological space.

Different studies distinguish CS from Peripheral Sensitisation (PS); in 2009 Sandkuhler described PS as an increased response followed by a reduction of the activation threshold of nociceptors (Sandkuhler, 2009). In fact, PS is characterised by the release of inflammation mediators such as prostaglandins, bradykinins, nerve growth factors, and substance P.

These functional changes can also explain some of the clinical findings attributed to SD, specifically, neurogenic inflammation which can be a key factor in generating TT alterations (Fryer, 2016).

Considering all these controversial topics, there is an absolute need for a new evidence-based model to better explain and possibly prove the existence of SD, its peculiar pathophysiology and related manifestations. This model should show relevant results in terms of diagnostic reliability and validity.

Finally, a new paradigm could be useful to clarify the clinical utility of SD, communication between practitioners, and training for students.

Therefore, starting from daily clinical practice and building a theory based on evidence from the literature, the purpose of this paper is to highlight a different aspect that could lead osteopaths during their functional assessment, i.e., the "movement variability" property of tissues.

Thus, a better understanding of SD complexity and its consequent clinical manifestation might be possible.

4. Different clinical signs of Somatic Dysfunction

Even if quantitative and qualitative analysis of movement, obtained by evaluating the Range Of Motion (ROM) and its "End-Feel", can be elements in motor function evaluation (Haneline, 2008), they are not sufficient to assess SD during distinctive physical examination in osteopathy. Probably a different motion analysis is required to detect variations of somatic function in its complexity, represented also by vascular and neural aspects (AACOM, 2017).

SD is characterised by positional asymmetry, that is the position of a body part referenced to its defined adjacent parts, and motion alterations described by the directions in which motion is freer and restricted (AACOM, 2017). Osteopaths describe SD using palpation of the bones to detect the relative position of a body part and the

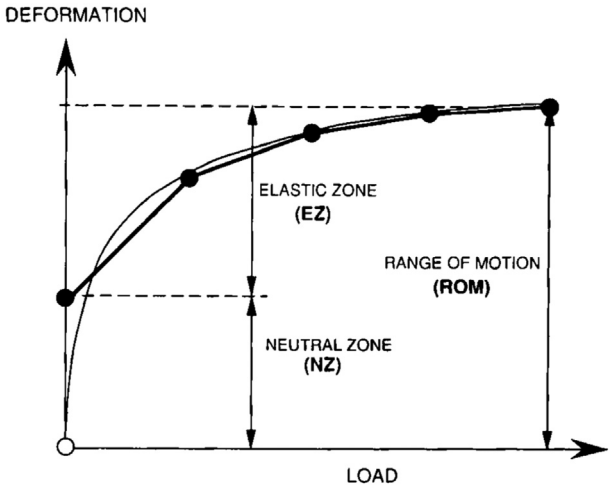

Fig. 2. Panjabi (1992), use with permission. The load-displacement curve of soft tissue or body joint is extremely non-linear. The joint is highly flexible for low loads and stiffens for increased loads: NZ, part of the ROM measured from the NP with minimum internal resistance; Elastic Zone (EZ), part of the ROM measured from the end of the NZ up to the physiological limit with significant internal resistance.

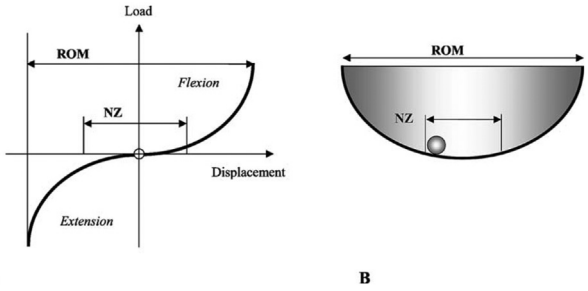

Fig. 3. Panjabi (2003), use with permission. Load-displacement curve: (A) a vertebral segment subjected to flexion and extension loads has a non-linear load-displacement curve, indicating a changing relationship between the applied load and the displacements produced; (B) a ball in a bowl is a graphic analogue of the load-displacement curve.

freer and limited joint movement. For example, a 'superior pubic shear' SD means a pelvic SD in which one pubic bone is displaced superiorly as compared to the normal contralateral pubic bone and its motion is restricted in the inferior direction and freer in the superior direction (AACOM, 2017).

The just mentioned description agrees with the International Classification of Diseases, classifying SD as a biomechanical lesion and considering different skeletal regions such as head, cervical, thoracic, lumbar, sacral, pelvic, lower/upper extremities, rib cage, and abdomen as an exception (ICD, 2018).

However, this definition does not explain exactly in which part of the ROM the osteopaths should assess motion. Nevertheless, as already discussed, asymmetries in the human body are common.

For the authors, the assessment of the range around the Neutral Position (NP) or Rest Position is essential to detect SD, its distinguishing asymmetry, and restriction of motion (see Fig. 1).

In the NP, stresses and strains of the passive (osteo-ligamentous) and active (muscle tendon) subsystems, and consequently the neurological activities for sensorimotor control, are at a minimum to stabilise the posture and motor function (Kumar and Panjabi, 1995).

Panjabi also identifies an area within the physiological motion range, called the Neutral Zone (NZ), in which movement is produced with minimum internal resistance. This area is characterised by high flexibility and is of utmost importance for joint stability (see Fig. 2).

NP thus expresses a "position" while NZ the possibility of movement with minimum resistance around that position.

Panjabi, by analogy, represents the loading-displacement curve using a bowl, obtained by overturning this curve around the displacement axis: a ball moves easily in the NZ while requiring greater effort in the distal zones of the ROM (see Fig. 3).

The Panjabi's model can be used to explain the clinical signs of SD concerning asymmetry and restriction of motion. In presence of normal somatic function, the ball is able to move in the NZ, "changing" its position with a minimal reaction of the stabilising subsystems: articular, muscular, and neurological. Thus, movement variability within the NZ expresses a normal somatic function. In an altered somatic function, the ball can move in one direction, but it requires a greater effort to move in the opposite one; it loses movement variability, with an asymmetry of motion within NZ. In this case, the resistance offered by passive structures is not minimal, and a neuro-muscular activity is required to maintain the position (see Fig. 4).

Recent results published by Dugailly et al. (2017) confirm the Variability Model proposed (see Fig. 5). The authors analysed stiffness during rotation of the upper cervical spine in patients with tension-type headache or migraine. The most significant difference, considering symptomatic and healthy subjects, was asymmetry in

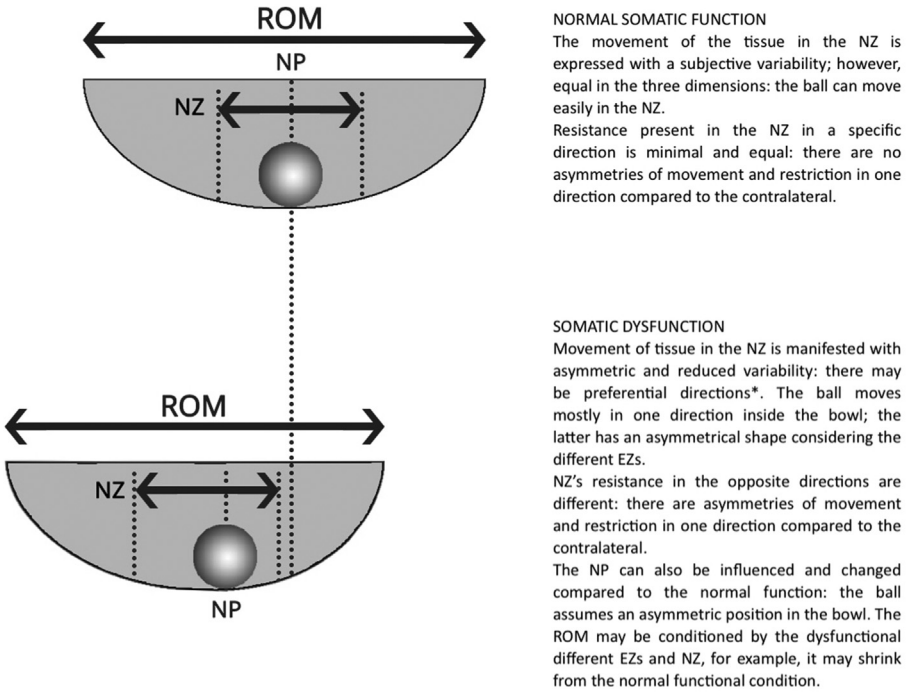

Fig. 4. NZ in the normal somatic function and in the SD. Normal somatic function: the ball is able to move easily in the NZ expressing movement variability. SD: the ball moves especially in one direction with an effort in the opposite one losing movement variability. *Preferential direction in SD is a phenomenon studied by Standley in his in vitro studies of human fibroblast cultures. For example, he suggests the existence of optimal strain patterns to treat different SDs (Zein-Hammoud and Standley, 2015).

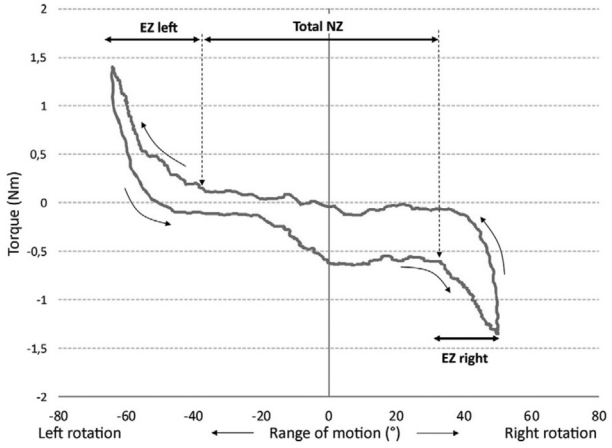

Fig. 5. Dugailly et al. (2017), use with permission. Graphic representation of the torque in relation to the range of motion in NZ and EZ during passive rotation of the upper cervical spine. The arrows indicate the direction of movement. The rotation has a nonlinear curve, an expression of a non-direct proportional relationship between the induced movement, and the load that is generated. The figure highlights how movement reaches the limits of the EZ, where the load peak is generated, in both directions. On the contrary, the forces developed are minimal within the range of NZ.

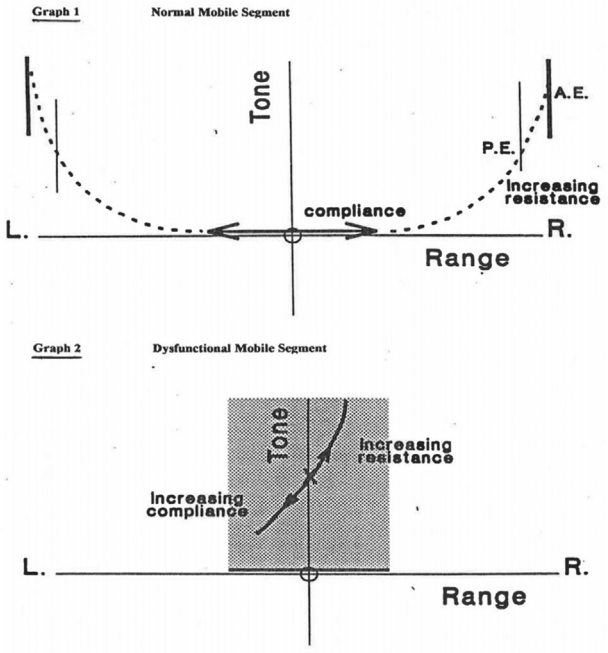

Fig. 6. Johnston (1995), use with permission. Schematic (unidirectional) representation of tensile responses to passive palpatory tissue testing by applying forces in opposite directions: Graph 1) a normally functioning somatic segment; Graph 2) a dysfunctional somatic segment, its altered NP is already active and tension is not minimal. P.E. = Physiological Barrier; A.E. = Anatomical Barrier; R. = Right; L. = Left.

the NZ between the right and left vertebral rotation in the clinical group. Hence, the movement variability expressed around NP. This study highlights the clinical relevance of an altered variability of motion in NZ. It should be considered that these patients may have neck pain (Ashina et al., 2015) and how this is related to the abnormal rigidity of the spine (Ingram, 2015).

Subsequently, Dugailly et al. (2018) investigated cervical spine stiffness in the left-right axial rotation among neck pain patients and asymptomatic subjects analysing the impact of Osteopathic Manipulative Treatment (OMT). Neck pain patients showed different stiffness characteristics compared to asymptomatic subjects, resulting in lower NZ values. After OMT, NZ and ROM were increased for the neck pain group only: patients showed significantly less neck pain immediately after treatment, suggesting a better tolerance to passive motion at the end of the range, and consequently leading to an increase of axial rotation. Finally, the NZ asymmetry reduction after treatment was mainly observed in the clinical group after intervention.

Jain et al. (2016) evaluated the ankle joint stiffness and NZ in inversion and eversion directions in subjects with chronic ankle instability on the involved and uninvolved limb. They were measured at baseline and after a four-week balance training intervention using a dynamometer. Although the results were not significant, ankles with instability showed more asymmetrical NZ ranges than uninvolved ankles at baseline. Moreover, the intervention group evidenced larger changes of NZs in inversion and eversion, with a relative reduction, compared to the control group at post-intervention.

In addition, Johnston et al. (1995) interpreted motor function considering afferences from a specific somatic region. In the NP of normal somatic function, afferences are minimal. On the contrary, in a dysfunctional area, alteration of the sensory afferent inputs influences motor control, vascular motility, and visceral functions through abnormal Autonomic Nervous System responses.

As shown in Fig. 6 - Graph 1, a normally functioning somatic segment expresses a baseline neurological afferent activity in NZ.

Conversely, in Fig. 6 - Graph 2, a dysfunctional somatic segment in its altered NP is already active and tension is not minimal.

Some recent studies can support these theories. Tecco et al. (2007), using Surface Electromyography (sEMG), analysed the activity of different muscle groups in subjects with different malocclusions. Then, in a subsequent study (Tecco et al., 2010), sEMG was observed in patients with different cross-bites; authors showed that monolateral posterior cross-bites altered activity of the anterior temporal muscle in NP; hyperactivity was found on the side of the dislocated jaw, comparing it to the contralateral side and to normal occlusion. Malocclusion produces an accentuated activity of the anterior temporal muscle bilaterally, or monolaterally, compared to that expressed in the normal occlusion, which is minimal on both sides (see Fig. 7).

These data could be interpreted in support of Johnston's theories where SD causes an alteration of motor control (afferences–efferences) with relative tensive forces (e.g., altered muscle activity) in NP. Collins et al. (2017) support the theory furthermore, with their research in which they recorded a variation in neurological activity as a result of changes in the degrees of tension.

Movement variability of the tissue within the NZ clarifies the SD clinical signs about positional asymmetry and restriction of ROM. Therefore, the authors propose an osteopathic physical examination where SD diagnosis is characterised by different clinical signs: tissue Texture abnormalities, NZ tissue movement variability, and Tenderness intended as all sensitisation phenomena.

Since Panjabi hypothesises a relationship between NZ and vertebral pathology (discal degeneration, skeletal lesions, and pain) (Panjabi 1992, 2003), and Latimer et al., (1996) demonstrated that the NZ portion was significantly different when measured before and following the resolution of pain, it is the opinion of the authors to suppose a correlation among NZ and somatic function, with its relative dysfunction.

5. How to palpate somatic dysfunction?

SD is not only determined by disorders of the musculoskeletal system, but also by the functional alterations of other related

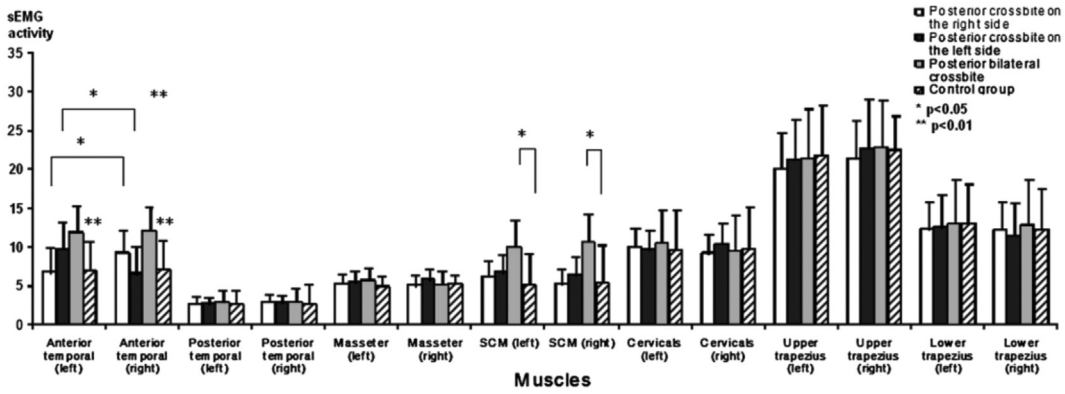

Fig. 7. Tecco et al. (2010), use with permission. Surface electromyographic activity of the muscles in mandibular NP in patients with different cross-bites.

systems: nervous and vascular. The close relationship between these elements, mediated by the fascial, nervous, and humoral systems, allows to identify a central element for somatic function during motion (Stecco, 2015). Osteopathic physical examination should detect all of the abovementioned characteristics at the same time. Considering the complexity of the human body, determinants of SD may be several (tissue, neural, and vascular) or one may prevail over the other.

In osteopathy, movement is mainly used to make a diagnosis (AACOM, 2017). During palpation, bone can be used to get information about the body position and mobility, so that it can be considered the most important "surrogate variable" to assess somatic functional changes. A surrogate variable, or biomarker, is the measurement of the effect of a specific biological state that may be related to a real clinical endpoint (Aronson, 2005). Therefore NP and the motion's variability in the NZ of the bones and consequently deep fascia and its musculoskeletal connections (Stecco, 2015) can represent SD.

During palpation of normal somatic function, movements of the tissues mediated by bones should show minimal or no resistance in NZ, i.e., they give a sensation of "Ease" (Chaitow, 2010; Nyberg and Smith, 2013) in all directions of each plane, expressing movement variability required for normal adaptive processes. In EZs, movements express a progressive increase in resistance with a perception of "Bind" (Petty et al., 2002; Chaitow, 2010; Nyberg and Smith, 2013).

Conversely, in SD, NZ is asymmetrical; during a movement, palpation detects an "Ease" sensation for a lower range in one direction accompanied by an increasing "Bind" in EZ in the same direction with less displacement compared to the opposite direction, confirming asymmetry and restriction of movement variability. Therefore, a dysfunctional somatic region expresses movement mostly in a direction, which is called "Permitted Motion".

This alteration creates the typical sensation of SD asymmetry and movement restriction, which helps osteopaths to take correct manipulative therapeutic choices, direct, indirect, or exaggeration techniques (AACOM, 2017; Parravicini and Bergna, 2017) (see Fig. 8).

Tissue characteristics are less influenced during evaluation if a gentle force is applied. Therefore, the assessment can be more specific and reliable, enhancing tactile perception as it may also allow for greater sensory discrimination of NZ. Indeed, a light force, used for quality of motion and its initial resistance-free movement

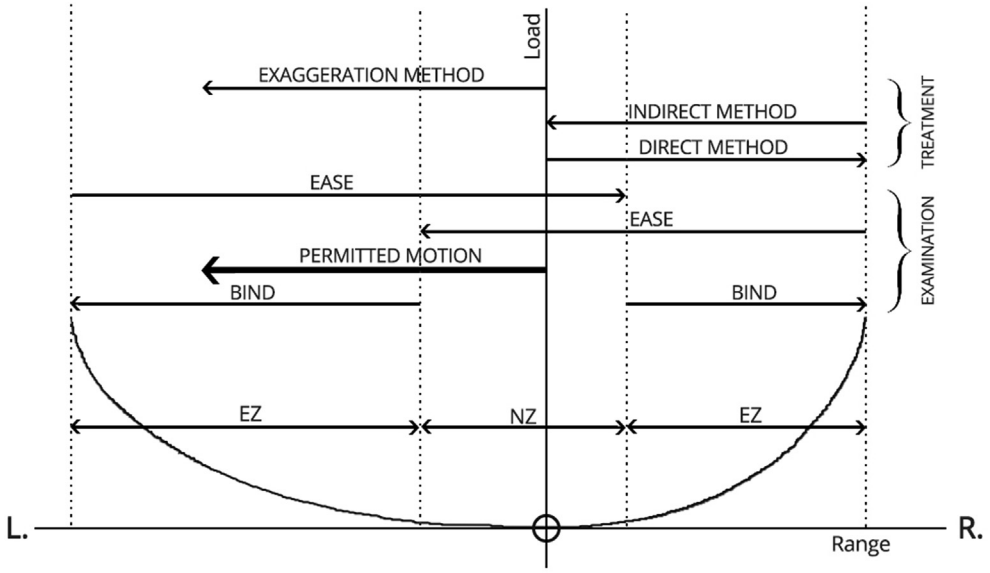

Fig. 8. Unidirectional schematic representation of dysfunctional tissue tensional response during a passive palpatory test. Palpation of Ease and Bind in NZ and EZs during examination and forces' directions of the manipulative techniques.

is more accurate than greater force, used for a quantity of motion and ROM palpation (Petty et al., 2002; Nyberg and Smith, 2013).

SD severity can be classified using the following scale:

- Grade 0 (Absent SD), movement variability in NZ present;
- Grade 1 (Mild SD), altered movement variability in NZ;
- Grade 2 (Moderate SD), altered movement variability in NZ + TT abnormalities or Tenderness;
- Grade 3 (Severe SD), altered movement variability in NZ + TT abnormalities + Tenderness.

SD is not only a musculoskeletal stiffness (AACOM, 2017) so it's not necessarily expressed by a ROM impairment (Sleszynski et al., 1999). However, it's common that quality influences the quantity of movement (Latash, 1993); thus, SD may present both articular and muscular stiffness that can be detected during a general motion test (Silva et al., 2018).

Particular attention should be given to flexibility, hypermobility, joint laxity, and joint instability. They are less frequent dysfunctional conditions related to congenital or acquired, ligament laxity with possible neuro-motor deficiency (Alter, 2004). There is a significant decrease in the stabilising system's ability to keep NZ within limits that are considered physiological (Panjabi, 1992). Palpation is characterised by excessive movement, both in increased NZ and ROM, with a flexible End-Feel (Hicks et al., 2003; Panjabi, 2003; Nyberg and Smith, 2013). In these cases movement variability within NZ variability can maintain asymmetrical characteristics and, moreover, its limits are no longer physiological (Panjabi, 2003).

6. Discussion

Considering movement variability as a potential diagnostic model, it is important to explain that the four TART clinical signs should be reinterpreted. For the authors, asymmetry and restriction parameters are to be intended only within the NZ; they are fundamental in the SD pathophysiological processes. Regarding this, it is hypothesised that an “in-range” examination (as the Variability Paradigm requires) does not produce tissue deformation, which is an aspect that can potentially increase diagnostic reliability.

Although tissue palpation continues to be performed during the osteopathic examination, the texture should not be thought of as the main parameter, considering its low levels of accuracy and reliability.

Moreover, tenderness is frequently present in SD clinical manifestation even if, as the authors stressed before, it requires a re-examination in view of the sensitisation phenomena.

All these clinical signs are interdependent and could appear in different combinations.

In the opinion of the authors, this Variability Paradigm could be related to the wider concept of “adaptation”, thus having implications in the primary meaning of health.

In this view, clinicians should consider their patients as a complex adaptive system where they are able to find new adaptations to achieve health (Thygeson et al., 2010).

Thus, adaptation is clinically associated with the concept of resilience, defined as the ability of a system to adapt to a change (McEwen, 2016) and the biopsychosocial model confirms this theory (Chandra and Leong, 2016).

The patients can be helped to build their adaptive capabilities in general, so that they are globally more adaptive, resilient and maximally autonomous producers of their health (Thygeson et al., 2010; McEwen, 2016).

To do that, clinicians should be able to give to the body of the patient various possibilities of choice or available options, i.e., more variability (Goldberger et al., 1990). In Blandford's words, ‘a wide choice of movement strategies should be available for use for a single movement task’ (McNeill and Blandford, 2015).

Yang and Tsai (2013) suggested that some pathologies derive from an absence of variability or complexity; nevertheless, an excess of variability (or a random variability) would lead to the pathological functioning of a system.

The therapeutic aim is to search for optimal variability of the body, maximising adaptive benefits and reducing expenditure (Schuldberg, 2015).

Health could be intended as ‘being optimally variable’, within the borders of variability (Bornas and de la Torre-Loque, 2016).

In the presence of the clinical signs of SD, the Variability Paradigm allows to interpret them as the attempt of the body system to maintain or restore a health condition.

Although the topics discussed in this manuscript are elaborated starting from evidence of the literature, the authors are aware of the limits of their proposal.

Primarily, the authors strongly support the idea that Variability Paradigm could be better than TART clinical signs in terms of reliability and diagnostic accuracy; anyway, at the moment, this represents only an assertion; research is needed to verify these hypotheses. In addition, if it can be assumed that palpation of movement variability could be easily studied in osteopathy related to the musculoskeletal system, the authors also have some concerns as regards visceral and cranial fields.

The authors have mentioned some studies (Tecco et al., 2010; Jain et al., 2016; Dugailly et al., 2017, 2018), as proof to enhance the Variability Model; this primary evidence surely deserve attention and consideration, even if they are built on studies carried out on relative small samples.

Finally, the authors conducted a non-systematic review in order to find elements in support of their clinical observation; this methodology would have allowed to easily detect all the arguments of interest but could have probably led to a lack of information.

The Variability Model has not any pretension to modify the fundamental bases of osteopathy, which the model fully contemplates through the evaluation of the capacity of adaptation and self-regulation expressed by movement variability, but rather to make explicit the palpatory evaluation of body movement typical of the osteopathic objective examination, through a parameter probably already used by osteopaths but not yet thoroughly studied, codified and organized.

Future prospects for research could be to assess its reliability and accuracy. The authors suppose that it will be possible to improve the inter-observer reliability after a consensus training as Degenhardt's studies have shown (Degenhardt et al., 2010). Moreover, it will also be useful to run validity trials to achieve SD clinical relevance and its feasibility. A particular application might be for newborn assessment, because it normally has a complicated SD classification.

7. Conclusions

The osteopathic physical examination includes quantity and quality motion. The Variability Model, while contemplating the TART clinical signs, interprets them differently considering movement variability the potential key factor in osteopathic palpatory diagnosis to detect the capacity of adaptation and self-regulation.

According to the authors, the assessment of the range around the NP, is essential to detect SD and its distinguishing asymmetry and restriction of motion. NP expresses a position, while NZ the possibility of movement with minimum resistance of passive structures and muscular efforts around that position.

In presence of normal somatic function, the movement of the tissues in the NZ is expressed with a symmetrical variability of motion around NP. On the contrary, an altered somatic function loses variability, with asymmetry of motion within NZ.

The proposed model aims to open new developments in osteopathic research, especially regarding high critical aspects such as palpatory reliability and SD clinical relevance. Variability Model, insert in the standard osteopathic diagnostic pathway, may improve reliability of distinctive physical examination in osteopathy considering the enhancing tactile perception and reduced tissue deformation due to the gentle force applied in the NZ assessment.

Although osteopathic care should always consider touch effects and other soft skills useful to interpret and integrate the biopsychosocial aspects of the patient, for the authors SD maintains a primary and distinctive role in osteopathic practice and in explaining its proven clinical relevance.

Furthermore, it is hoped that the objective and instrumental examination could be combined in order to enhance the osteopathic diagnostic accuracy.

Considering the SD clinical signs from this new perspective, a desirable outcome could be a better characterisation of osteopathy in the biomedical field even if further research is needed to improve and validate these theories.

Declarations

Authors' contributions: AB realised and described the Variability Model and how to palpate it. GP and FD performed the reviews, particularly for critical analysis of the TART clinical signs. LV performed the implications for practice described in the discussion.

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List of Abbreviations

CNS	Central Nervous System
CS	Central Sensitisation
EMG	Electromyographic
EZ	Elastic Zone
LBP	Low Back Pain
NP	Neutral Position
NZ	Neutral Zone
OMT	Osteopathic Manipulative Treatment
PS	Peripheral Sensitisation
ROM	Range Of Motion
RP	Rest Position
SD	Somatic Dysfunction
sEMG	Surface Electromyography
TT	Tissue Texture

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