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The Thrust – A Must?

A literature review of the effectiveness of thrust manipulation for pain relief in musculoskeletal conditions

Metropolia University of Applied Sciences

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Abstract

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Background: Musculoskeletal pain is a quite common, disabling, and costly issue in our society. A technique used by manual therapists to facilitate pain relief for these conditions is the high-velocity/low-amplitude thrust (HVLA-T) and while there exist studies showing its effectiveness for pain relief in specific regions or conditions, such as for non-specific lower back pain (NLBP), there is not much data regarding its pain relief qualities in a broader sense.

Objective: To investigate the effectiveness of HVLA-T in terms of pain relief for patients suffering from musculoskeletal conditions.

Method: A review of current literature (<=5y) on CINAHL and PubMed.

Result: 8 articles were considered eligible, compromising a total of 873 participants. Articles included were assessed for quality through use of the PEDro scale as well as assessed with regards to ethics. A trend of significant and often clinically important reductions of pain and pain-related aspects was shown.

Conclusion: HVLA-T is an effective manual technique in terms of pain-relief to a subgroup of patients suffering from musculoskeletal conditions. However, there is not significant difference in between-group comparisons of other techniques or sham procedures. More research is needed into the mechanisms of HVLA-T to find the ruling factor of patient outcomes as well as a comparison of different manual therapeutic modalities for pain-relief.

Keywords: Thrust Manipulation
Osteopathy
Manual Therapy
Pain

Declaration of conformity

Both of us, i.e., the authors, assure on oath to have created this present work independently between ourselves, and to have exclusively used the sources and aids indicated within it. The idea of the study was conceived by us both and there has been an equal contribution to the design and concept, data collection and analysis, as well as construction of the manuscript. We have both read and approved the manuscript, and this thesis has not been submitted anywhere else. We declare that we have no conflict of interest with any person(s) or institution(s) and no funding was provided to either of us.

Per Munke Cross, Gothenburg, 2022-03-20

Victor Ingvi Jacobsen, Reykjavik, 2022-03-20

Table of Contents

Abbreviations

WHO	World Health Organization
MSC	Musculoskeletal Condition
LBP	Low Back Pain
HVLA-T	High Velocity Low Amplitude Thrust
HVT	High Velocity Thrust
CT	Connective Tissue
SI-JOINT	Sacroiliac Joint
CNS	Central Nervous System
PNS	Peripheral Nervous System
SNS	Somatic Nervous System
ANS	Autonomic Nervous System
IASP	International Association for the Study of Pain
VAS	Visual Analogue Scale
NPRS	Numeric Pain Rating Scale
QOL	Quality of Life
PPT	Pain Pressure Threshold
ROM	Range of Motion
AP	Audible Pop
EMG	Electromyography
MFR	Myofascial Release
FD	Flexion-Distraction
RCT	Randomized Control Trial
SMT	Spinal Manipulation Therapy
TS	Temporal Summation
JPSE	Joint Position Sense Error
NDI	Neck Disability Index
PCC	Person-Centred Care
MIH	Manipulation-Induced Hypoalgesia

1 Background

1.1 Introduction

Regardless of who you are, you will most likely sometime during your lifetime experience some form of musculoskeletal condition (MSC), and the World Health Organization (WHO) even estimates that around 1.7 billion people currently suffer from some form of MSC. Adding insult to injury, that number is continuing to rise. (WHO, 2021)

MSCs are characterized by *"pain (often persistent) and limitations in mobility, dexterity and overall level of functioning"* and compromise more than 150 conditions ranging from transient conditions to lifelong chronic ones. These conditions, like the name implies, are not limited to only a certain region or tissue, but can affect anything from joints, bones, and muscles to multiple areas and systems in the body. One of the most prevalent MSC is lower back pain (LBP) which affects almost 570 million people and is also the biggest contributor to disability in 160 countries as well as the main reason for premature exit out of the workforce. Another similar MSC is neck pain which affects around 222 million people. (ibid)

As a response to all of this, the Rehabilitation 2030 initiative was set in motion by the WHO in 2017 to draw attention to the profound unmet need for rehabilitation worldwide and highlight the importance of strengthening health systems to provide rehabilitation.

For manual therapists, there are many approaches to ameliorating the pains that people who are suffering from MSC might experience, and thus working in line with the prior mentioned WHO initiative. One of these is the *high-velocity/low-amplitude thrust* (HVLA-T), also known as *high velocity thrust* (HVT) which, although often spoken highly about within circles of manual therapists, arguably does not have enough evidence to support some of the proposed positive effects.

1.2 Relevant Anatomy

1.2.1 Arthrology

The human body contains over 200 bones, varying in both size and shape, and they are connected by joints which enable mobility and stability. Our joints can be classified based on structure and how much they can move. Structurally, joints can be divided into *fibrous*, *cartilaginous*, or *synovial*, depending on the connective tissue (CT) which binds the bones together, or the presence/absence of a synovial joint cavity. These can then be further categorized into *synarthrosis*, *amphiarthrosis*, and *diarthrosis* - referring to the degree of movement a joint can execute. (Levangie, Norkin and Lewek, 2019)

The anatomical structure of a synovial joint is unlike the one prevalent in fibrous and cartilaginous joints. Examples of synovial joints include the elbow and knee joint, as well as the spinal facet joints and the sacroiliac joint (SI-joint). In this type of joint there is no CT directly uniting the adjacent bones. Instead, they are indirectly connected by a fibrous joint capsule lined in synovium. (ibid)

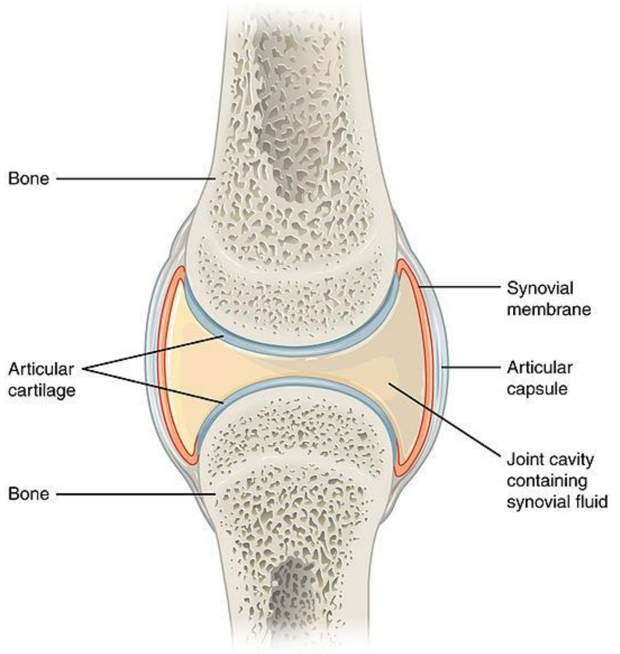


Fig 1 - Schematic image of a synovial joint. *(OpenStax College, CC BY 3.0 <https://creativecommons.org/licenses/by/3.0>, via Wikimedia Commons)*

Seen in **Fig. 1** is a common schematic image of synovial joints with a *joint cavity* encapsulated by a *fibrous joint capsule* where the inner surface is lined with a *synovial membrane*. Covering the articular surface of the bones is a sheath of *hyaline* or *articular cartilage*. Within the capsule is also a *synovial fluid* which forms a film over the joint surface. (ibid)

1.2.2 Myology

Our bodies contain more than 600 muscles which we need for a multitude of functions such as locomotion, maintenance of posture, respiration, and contraction of organs and vessels. Like our joints, muscles can be divided into different types depending on their function. There are three different types of muscles: Smooth muscle, which can be found in the walls of hollow organs and is the most widely distributed muscle type in the body, cardiac muscle, which just as the name implies, can be found in the heart, and skeletal muscle (VanPutte et al., 2020).

A skeletal muscle is composed of fascicles (i.e., bundles) of muscle fibres formed by a multitude of *myofibrils*, which in turn consists of *sarcomeres* - the structural and functional contractile units of skeletal muscles. The sarcomeres have an alternating pattern of thick and thin *myofilaments*: *myosin myofilament* respectively *actin myofilaments*. The thick myosin myofilament is anchored at the centre of the sarcomere (which is known as the *M-line*), and the thin actin myofilaments are anchored to the other edges of the sarcomere (the *Z-disk* or *Z-line*) (**Fig. 2**) (ibid).

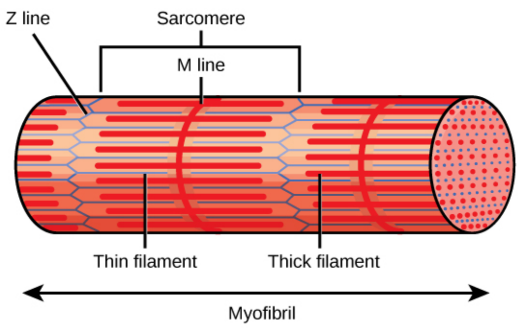


Fig. 2 Fibre structure of skeletal muscle myofibril. *(CNX OpenStax, CC BY 4.0 <https://creativecommons.org/licenses/by/4.0>, via Wikimedia Commons)*

Skeletal muscle, as opposed to both smooth and cardiac muscle, is the only muscle type which can be voluntarily controlled. It attaches to our bones via tendons or fascial structures, and when contracted, facilitates movement.

1.2.3 Neurology

Virtually everything our body does is controlled by the nervous system, and without it structures like muscles and joints would not be able to facilitate movement.

Our nervous system has two major divisions: the *central nervous system* (CNS), consisting of the brain and the spinal cord, and the *peripheral nervous system* (PNS), which constitutes the remaining nervous tissue outside the CNS (e.g., Nerves and ganglia), and these two systems work together to maintain homeostasis (i.e., A state of internal balance, allowing for proper bodily functions). The CNS can be seen as a *key decision maker*, and it receives information from the PNS which it then processes to deliver a decision of how the body should respond**.** As with many parts of our anatomy, further divisions can be made, and in the case of the PNS it can be divided into a sensory, and a motor division. (VanPutte et al., 2020)

The sensory division of the PNS can transmit electrical signals from sensory receptors in our body towards the CNS, and it does this via nerves extending from the receptor to the brain or spinal cord. The CNS can then via the motor division transmit an electrical signal to an *effector organ* to facilitate a proper response. For instance, turning on a bright light in a dark room will make the sensory receptors in the eye send a signal to the CNS, which then responds by transmitting electrical signals to the motor division to constrict the pupil. (ibid)

Just as the PNS, the motor division can be divided further, and in this case in two branches: the somatic nervous system (SNS), and the autonomic nervous system (ANS). The SNS is the branch of the motor division which can be voluntarily controlled - such as moving your arm to pet a dog. This is facilitated by electrical impulses from the CNS sent to the effector organ (in this case, the skeletal muscles of the upper extremity). The ANS, on the other hand, cannot be voluntarily controlled, but rather regulates different activities without any conscious action from the organism. For instance, raising your heart rate when finding out that dog was, in fact, a vicious wolf. (ibid)

In this unexpected realization that the dog was in fact a wolf, another subdivision becomes interesting, and that is the sympathetic division of the ANS. This division is responsible for what is sometimes referred to as the *fight-or-flight* response. The other end of the spectrum, and also a branch of the ANS, is the parasympathetic division, which is responsible for functions related to rest - such as digesting food, lowering the heart rate. This is also known as the *rest-and-digest division*. (ibid)

Our nervous system is not only important when it comes to bodily functions such as movement, but also regarding pain and how it's processed.

1.3 Pain

1.3.1 Introduction to pain science

Pain is a complicated topic, but a standardized definition of it comes from the International Association for the Study of Pain (IASP), which defines pain as an "*unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage".* The last part of the definition is important to emphasize as pain and *nociception* are different. A further expansion of the definition of pain from the IASP that follows is how "*Pain is always a personal experience [...]".* This is important for clinicians to remember, as questioning a patient's experience of pain means questioning their unique and subjective experience (2011).

While the different terms in some cases are used synonymously, it is good to differentiate between *nociception* and pain. Pain, as mentioned, is an experience, while nociception on the other hand is *"[...] neural process of encoding noxious stimuli*". Nociception can result in a person experiencing pain, but it is not a requirement. In other words, both pain and nociception can co-exist, but can also take place regardless of the presence of the other (ibid).

Nociception relies on specialized peripheral neurons called *nociceptors* which can detect a stimulus that might harm the organism. These nociceptors can be stimulation-specific, and respond to a certain type of stimulus, such as mechanical, chemical, or temperature, but they can also be *polymodal* and respond to multiple types of stimuli (Al'Absi and Flaten, 2016). When a nociceptor is stimulated, a signal is sent to the CNS. This signal is transmitted via peripheral nerves, terminating in the dorsal horn of the spine, up to the thalamus. After this the signal is relayed to various structures of the brain including the amygdala and hypothalamus. Once here, the information is processed, and depending on a multitude of factors, including (but not limited to) cognitive and emotional experience, a different response can be produced (Garland, 2012).

An example of how the processing of pain and the response can differ depending on non-nociceptive-related factors can be seen in Moseley and Arntz. (2007). In this experiment, subjects had a -20°C rod placed on their hand for 500ms while observing a visual cue and depending on the colour of the cue the sensation was perceived differently. If the cue was blue, the subjects perceived the stimuli as cold, and if it was red, they perceived it as hot. Another example can be seen in Harvie et al. (2015), featuring subjects with movement-evoked neck pain. The subjects wore a virtual reality headset and when the visual feedback was modified, either over- or understated, the subjects felt less respectively more pain than without the headset. These are just a few examples of how external changes can modify the experience of pain.

While there are probably people who wish they would not experience pain for various reasons, it deserves to be mentioned that pain serves an important function for survival, as pain is an adaptive response helping the organism survive by alerting it to avoid potential dangers (Garland, 2012).

1.3.2 Measuring Pain

There are multiple tools available to assess pain and factors related to it, and these tools have their differences as well as strengths and weaknesses. Examples include the arguably simpler Visual Analogue Scale (VAS) and Numeric Pain Rating Scale (NPRS) – both unidimensional – or instruments that might address more factors such as Quality of Life (QOL), disability, and more. Examples of the latter include the Penn Shoulder Score.

The VAS is a visual tool which can be used to assess pain intensity. It is often presented as a line of fixed length, usually 100mm, with the ends of the line being affixed with terms such as *'no pain'* or *'worst imaginable pain'* (Streiner, Norman and Cairney, 2015) however there can be some differences in how the scale is presented. To use the tool a patient can mark somewhere on the line to evaluate their intensity of pain and thus provide the clinician with a score out of 101 (Williamson and Hoggart, 2005).

NPRS shares its simplicity of use with VAS but differs in other ways. The scale can be presented verbally or visually and usually as an 11-, 21-, or 101-point scale – however discrepancies exist. When it is presented visually it is often done so with enclosed boxes and, just as VAS, with terms like *'no pain'* and *'pain as bad as it could be'* affixed to opposite ends (ibid).

While these two tools do serve their purpose in assessing pain, they are still unidimensional, and as such, clinicians might need a tool assessing multiple dimensions. The Penn Shoulder Score previously mentioned is an example of this and it is a *condition-specific self-report measure* consisting of 3 subscales: Pain, satisfaction, and function. The section used to assess pain includes questions addressing pain at rest, during normal activities, and at times of strenuous activities, and while the instrument is more than just a pain assessment tool, the pain-related questions are based on a 10-point NPRS scale (Leggin et al., 2006).

On top of this, aspects of pain can also be assessed with external equipment. An example of this is with Pain Pressure Threshold (PPT) which is used to measure tissue sensitivity of muscles. PPT is often administered with an algometer which applies a non-painful pressure to a muscle. and this pressure is then increased until the sensation of pain is experienced. However, there exists no standardized protocol for this measurement (O'Hora et al., 2020).

The tools for evaluating and assessing pain are all presented in Appendix A.

1.4 Manual Intervention

1.4.1 Thrust Techniques

Thrust manipulation techniques (i.e., HVLA-Ts) are often used by manual therapists (e.g., Osteopaths, chiropractors, and physiotherapists) to manage and treat a variety of musculoskeletal conditions. As the old Swedish saying goes, *a dear child has many names*, and this is the case for this technique. Thus, for the sake of semantic consistency, the authors have opted to use the term *HVLA-T* as the term to describe the technique - independent of the term the articles included use to describe the technique.

The technique aims to move a joint outside of its normal physiological range of motion (ROM), in the direction of a suspected barrier, and while doing this, not exceed the anatomical ROM limit. The practical execution of the technique can be explained as a manual technique which implements a rapid use of force (*high velocity*) over a short distance (*low amplitude*) to elicit a release in an anatomical *restriction* of a synovial joint (LaPelusa and Bordoni, 2022). This supposed *restriction* is a topic which is debatable because while clinicians can spend a long time investigating where the correct region to apply a HVLA-T to lies, current evidence does not seem to support the notion that applying the technique in a "clinically relevant" site is better than applying it to a "not clinically relevant" (Nim et al., 2021).

When applying a HVLA-T to a joint, sometimes a *cracking* or *popping* sound can be heard. This phenomenon is known as *cavitation* and is often referred to as an audible pop (AP). While it historically has been thought to be emitted because of a collapse of a gas bubble within the synovial fluid of the joint, recent findings indicate that this sound is rather a result of cavity inception within the synovial fluid. I.e., formation, rather than a collapse, of the bubble (Kawchuk et al., 2015). This AP, however, is not always present during a HVLA-T and current evidence does not support the notion that it even matters if it is present or not (Bialosky, Bishop, Robinson and George, 2010; Sillevis and Cleland, 2011). There may also be an increased risk of adverse effects if clinicians repeat the technique in hopes of getting the joint to cavitate (Bakker and Miller, 2004).

The purpose of the technique varies with a range from inducing neurophysiological, circulatory, endocrine, or psychobiological changes, to improving ROM, and the technique also has some proposed hypoalgesic effects (Bialosky et al., 2009).

While the technique is applied to a joint, the effects do not seem to only appear in the joint to which the technique is being administered to, but can also manifest itself in other tissues, such as with decreased resting electromyography (EMG) activity, or decreased muscle inhibition. There are also proposed spinal mechanisms at play, as well as supraspinal structures influencing the response to pain. However, the mechanisms by which HVLA-T produces its effects are not yet completely established. (ibid)

When addressing the question of when to administer a HVLA-T, the waters become murky. Chila (2011) states how the practitioner administering it must *"[...] learn to perform a palpatory diagnosis"*. However, the discussion of reliability of a palpatory diagnosis is up for debate as it varies greatly (Nolet et al., 2021), and some findings even show that identifying pain and motion restrictions has a poor reliability, even when performed by experienced examiners (Walker, Koppenhaver, Stomski and Hebert, 2015). Some clinical prediction rules exist, but often only address one condition. For low back pain one example is presented by Childs et al. (2004) and consists of the following:

- symptoms existed for less than 16 days,
- no symptoms distal to the knee,
- low fear-avoidance behaviour,
- one or more hypomobile vertebral segment(s),
- one or more hip(s) with more than 35° of internal rotation ROM.

1.4.2 Alternative Techniques

The HVLA-T is not the only technique which manual therapists can opt for. Rather, there exists an abundance of techniques which can be used. One example of this is myofascial release (MFR), an umbrella term which often involves *"slow, sustained pressure"* applied to the *fascia* (a "*soft tissue component of the connective tissue"*). This is done either directly, or indirectly, to restore an optimal length of the fascia, as well as decrease pain and improve function. (Ajimsha, Al-Mudahka and Al-Madzhar, 2015). While proponents of MFR might suggest that the technique works by changing the structure of the fascia, it most likely works via stimulation of mechanoreceptors rather than an actual plastic change, as the tissue is very tough, and any plastic changes would require high (and dangerous) amounts of mechanical pressure (Schleip, 2003). Two other techniques which can be used by manual therapists are flexion-distraction (FD) techniques, or a non-thrust mobilization.

The FD technique is administered by having the patient in a prone position on a special type of bench suited for the technique. The bench helps in creating a distraction and flexion motion at the intervertebral joints, and it is hypothesized that this facilitates an intradiscal decrease in pressure which can assist in reducing a disc protrusion as well as reducing pain and a fair amount of other proposed effects (Haldeman, 2004). Defining non-thrust manipulation (also known as *mobilization*) arguably is a bit harder, as the technique can differ from article to article, but generally it is associated with a passive procedure which does not involve a thrust and is also performed *"[...] well within the anatomical range of the targeted segment*" (Cook, 2012).

1.5 Osteopathic Approach

Osteopathy, sometimes called *osteopathic medicine*, is a manual medicine (i.e. diagnosis and treatment rely on manual contact), which puts much emphasis on holism. Practitioners of osteopathy use their medical knowledge to try to optimize the body's inherent self-regulating and self-healing capabilities - often with an approach based in the *osteopathic principles*. The discipline was created by Andrew Taylor Still in the late 19th century. Still was a physician as well as a surgeon and was the first man to establish a school of osteopathy. (WHO, 2010)

Since Still created osteopathy, many attempts to interpret his writings have been made, especially in regards to the so called osteopathic principles, and while there have been modifications to these a multitude of times from various people (Stark, 2013), the general fundamentals still remain the same and a current interpretation is as follows: "*The human being is a dynamic unit of function", "The body possesses self-regulatory mechanisms* *that are self-healing in nature"*, *"Structure and function are interrelated at all levels"*, and *"Rational treatment is based on these principles"* (Chila, 2011).

With these principles in mind, it can be argued that the osteopathic approach to health is one with focus on patient-centring with its roots in a holistic perspective. When the osteopath meets a patient, they do not see a disease-ridden person, but a person with their own experiences, trials, and tribulations who happens to be suffering from some condition - whether it be something such as idiopathic and benign back pain, to something more severe such as cancer. And, in terms of management for MSC, osteopathy could be a good complement to primary care. For instance, some evidence exists that osteopathy could be a good first-line management for various MSCs (Vaucher, Macdonald and Carnes, 2018).

1.6 Problem Statement

When it comes to how effective a HVLA-T is as a clinical technique for management of the eventual pain that follows along with MSCs, the evidence is, if but only at the moment, inadequate. While there exist articles showing positive outcomes of the technique, it is hard to determine if it is the technique itself producing these results. This may be attributed to the inherent hardships of examining the techniques with the golden standard randomized control trials (RCT) - for instance it is possible to randomize and blind both the subject and the clinician when studying pharmacological substances, but it is much harder (if not impossible) to blind a manual practitioner administering a technique such as a HVLA-T. On top of this the research usually focuses on one specific region or condition, such as in LBP patients, but there has not been any real focus on whether this effect is unique for the region studied or if the same effect can be applied in a different region.

2 Objective

The aim of this study is first and foremost to investigate whether a HVLA-T is an effective treatment intervention to elicit pain-relief in patients suffering from pain associated with musculoskeletal conditions. On top of that another objective is also to investigate whether there are any differences in effectiveness depending on which region of the body the technique is administered to.

2.1 Research Questions

Is a HVLA-T an effective clinical tool for eliciting pain relief in patients suffering from musculoskeletal conditions

Is the pain relief of a HVLA-T prevalent regardless of which region of the body the technique is being administered to?

3 Method

A literature review will be carried out, and the online databases PubMed and CINAHL will be used for collection of data. In the search string, terms such as *spinal manipulation*, *SMT* (Spinal Manipulation Therapy), or similar terms pertaining to the spine, have not been used. This to widen the results to include articles where a HVLA-T is applied to peripheral joints.

3.1 Keywords

The search query which will be used is *"((hvla) OR (hvt) OR (high velocity low amplitude) OR (high velocity thrust) OR (thrust manipulation)) AND (pain)"*

3.2 Inclusion and Exclusion criteria

This literature review will include or exclude articles in accordance to the criteria presented in **Table 1**.

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
• Articles published in the PubMed database • Articles published in the CINAHL database • Randomized Control Trial • Studies in English or Swedish • Studies where at least one of the intervention groups received a HVLA-T as sole treatment. • Studies performed on humans. • >=50 participants • Publishing date 2016-2021	• Reviews • Dissertations • Studies where not all patients suffered from MSC • Studies where pain is not a measured outcome • Studies where the HVLA-T intervention group contains additional forms of manual treatment • Articles where the manipulation is instrument-assisted

3.3 Screening of Studies

To determine eligibility of articles appearing in the database search, both authors will independently review the articles and then compare results.

3.4 Study Assessment

To assess the quality of the articles, the Physiotherapy Evidence Database (PEDro) scale will be used. The scale is a 10-item tool used to assess the methodological quality of RCTs of or pertaining to physiotherapy. The scale has shown a ‘fair’ to ‘excellent’ inter-rater reliability when applied to clinical trials concerning interventions related to physiotherapy (Cashin and McAuley, 2020). Both authors intend to assess the articles and grade them independently. This data will then be entered into a Google Sheets spreadsheet (2006 Google LLC, USA) and compared. Any inconsistencies between the two authors' scoring of the articles will be resolved by discussion. The PEDro scale can be found in Appendix A.

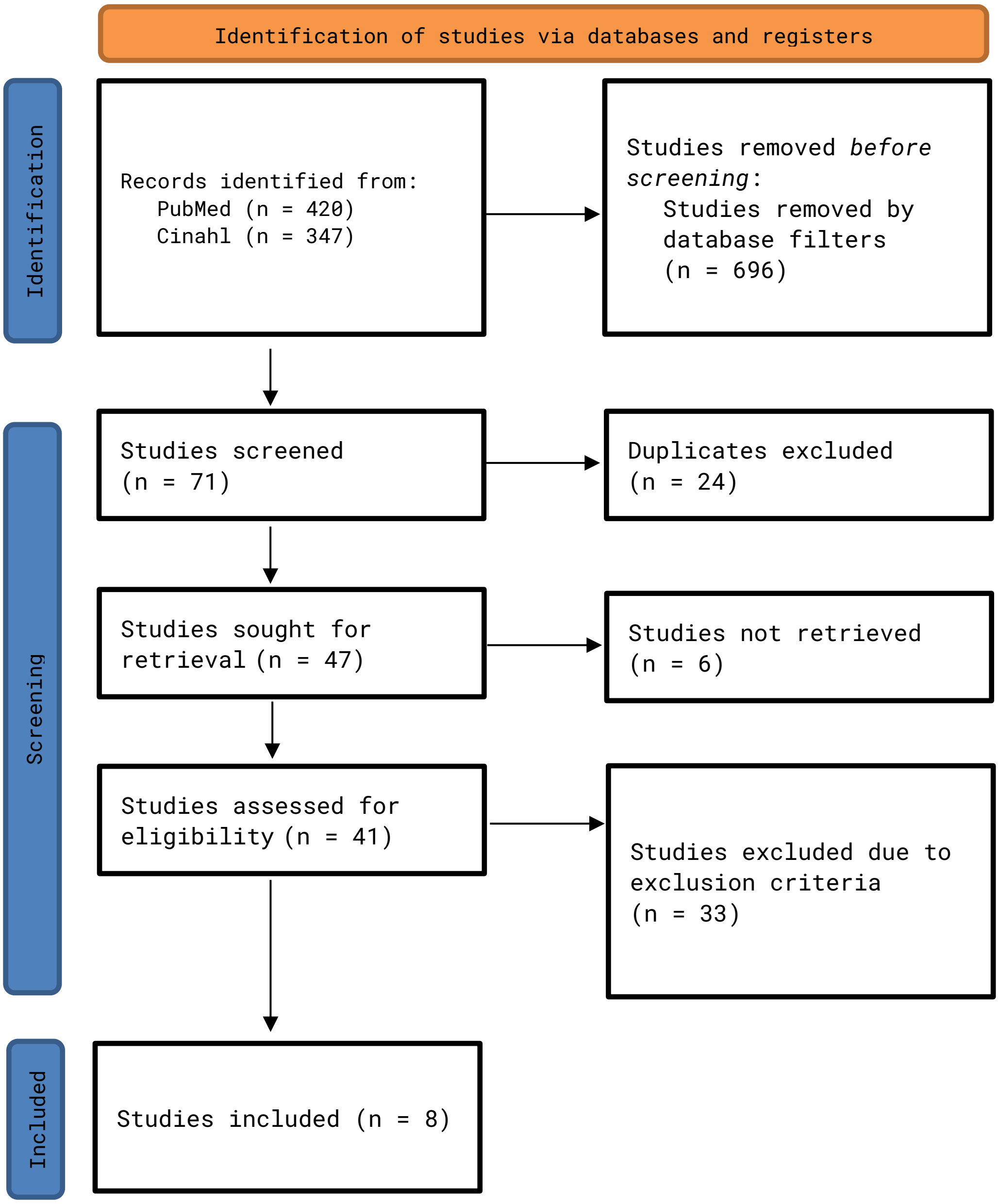
There will also be an evaluation of ethical considerations executed in accordance to the protocol presented by Weingarten, Paul and Leibovici (2004), which will be performed to bring awareness to the need for a solid ethical standard in osteopathic research. The protocol is a four-part tool used to investigate potential flaws in the ethics of systematic reviews and consists of 10 different questions unequally divided into 4 different areas: (a) Goal related considerations, (b) Duty related considerations, (c) Rights related considerations, and (d) Global considerations. This too is intended to be assessed by both authors independently, then compared via different spreadsheets, followed by any eventual inconsistencies being resolved by discussion. The protocol can be found in Appendix A

4 Results

4.1 Selection Process

A total of 767 articles were identified after the initial database search. After applying the database filters there were 71 articles left, which then were reduced to 47 when duplicates had been removed. This was followed by the remaining articles being sought for retrieval. If an article could not be accessed via the authors' university access, it was excluded. A total of 6 articles were excluded for this reason, leaving 41 articles which were assessed with inclusion and exclusion criteria. After this process, 8 articles were left for inclusion, compromising 873 participants. See **Fig. 3** for visual presentation of selection process.

Fig. 3 Flow chat of selection process.



4.2 Assessment of included articles

4.2.1 PEDro Scale

The PEDro score of included articles averaged at 7.6/10, with a range from 6/10 to 9/10. Lowest scoring item amongst all articles was item 6 (blinding of therapist) where not a single article received a point. The PEDro score of included articles ranged from a “fair to excellent” score. A full breakdown of the PEDro assessment is presented in **Table 2**.

Table 2. Quality Assessment for included studies (PEDro Score)

Author(s) (Study ref.)	1[a]	2	3	4	5	6	7	8	9	10	11	Tot.
Aspinall et al., 2019a (1)	✓	✓	✓	✓			✓	✓	✓	✓	✓	8
Boff et al., 2020 (2)	✓	✓	✓	✓			✓		✓	✓	✓	7
Carrasco-Martínez et al., 2019 (3)	✓	✓	✓	✓			✓	✓	✓	✓	✓	8
García-Pérez-Juana et al., 2018 (4)	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	9
Grimes et al., 2019 (5)	✓	✓	✓	✓	✓			✓	✓	✓	✓	8
Griswold et al., 2018 (6)	✓	✓	✓	✓			✓	✓	✓	✓	✓	8
Thomas et al., 2020 (7)	✓	✓		✓			✓	✓		✓	✓	6
Xia et al., 2016 (8)	✓	✓	✓	✓			✓	✓	✓	✓	✓	7

a. Not counted towards total score

See Appendix A for the PEDro scale.

4.2.2 Ethics Assessment

In terms of ethical considerations there was some variance in the assessment of included articles. As stated in 3.4 Quality Assessment an evaluation of ethics was carried out using the protocol presented by Weingarten, Paul and Leibovici (2004), and the written summary of said evaluation, which follows this paragraph, is also presented as a table in **Table 3**. For a more in-depth explanation of the protocol see Appendix A.

1. *Declaration of financial support* — Seven out of the eight trials had a clear declaration of financial support. Only one (3) did not. Out of the trials which did declare financial support, four articles did receive funding (1, 2, 7, 8), while three did not (4, 5, 6).

2. *Conflict of interest* — Half of the articles had a clear declaration of eventual conflict of interest. Out of the remaining half, two did not have any declaration at all (3, 8), and two studies declared financial conflicts, but did not explicitly refer to it as conflict of interest (5, 7; marked "?" in **Table 3**).

3. *Comments on justification* — Every article justified their sample size calculation, although one article (6) did not include enough participants and in another article (8) the power was too low in accordance with Di Stefano. (2003). Both marked "?" in **Table 3**.

4. *Publication bias* — This item was excluded from the assessment due to lack of statistical knowledge from the authors. Marked "n/a" in **Table 3**.

5. *Appropriate comparators* — For the sake of this review any other manual technique was considered appropriate if a justification for why the comparison had been chosen was made. In the case for sham or placebo manipulation it was considered appropriate if the sham technique was previously validated or its use was justified in-text. With these criteria only one article (4) did not have an appropriate comparator as no reason was stated for why it was chosen.

6. *Safety of participants* — By the exclusion criteria the authors ruled that severe pathologies would not be present. Thus, any article which assessed adverse events was considered appropriate. There were three articles (1, 3, 5) which did not satisfy this criterion.

7. *Informed consent obtained* — Every article obtained informed consent.

8. *Reduced competence* — Any participant of a younger age than 18 was considered of reduced competence, but no article included any participants under the age of 18.

9. *Confidentiality* — There were no articles which stated any attempts to uphold patient confidentiality and/or privacy.

10. *Approval by research ethics committee* — Half of the included articles were approved by some research ethics committee. Out of the other four which weren't, two were however approved by one or more university boards (5, 6; marked "?" in **Table 3**)

Table 3. Assessment of ethics using the Weingarten, Paul and Leibovici (2004) protocol.

Author(s) (Study ref.)	1	2	3	4	5	6	7	8	9	10
Aspinall et al., 2019a (1)	✓	✓	✓	n/a	✓	✕	✓	✓	✕	✓
Boff et al., 2020 (2)	✓	✓	✓	n/a	✓	✓	✓	✓	✕	✓
Carrasco-Martínez et al., 2019 (3)	✕	✕	✓	n/a	✓	✕	✓	✓	✕	✓
García-Pérez-Juana et al., 2018 (4)	✓	✓	✓	n/a	✕	✓	✓	✓	✕	✓
Grimes et al., 2019 (5)	✓	?	✓	n/a	✓	✕	✓	✓	✕	?
Griswold et al., 2018 (6)	✓	?	?	n/a	✓	✓	✓	✓	✕	?
Thomas et al., 2020 (7)	✓	✓	✓	n/a	✓	✓	✓	✓	✕	✕
Xia et al., 2016 (8)	✓	✕	?	n/a	✓	✓	✓	✓	✕	✕

For more info about the protocol used, see Appendix A.

4.3 Overview of studies

A tabular overview of articles combined with in-text reference is shown in **Table 4.** An in-depth overview of the articles and their results is included in Appendix B.

5 out of 8 articles' population consisted of individuals with some form of low back pain (1, 2, 3, 7, 8), while 2 other articles had a population with neck pain (4, 6). The remaining article (5) was unique in being the only one featuring a population where the pain was not related to the neck or back, but rather people with subacromial pain syndrome.

The control group(s) in the articles either opted to use some other manual technique (3, 6, 7, 8), a sham HVLA (1, 4, 5), or an extra technique in conjunction with the HVLA (2), however in two of the articles there were two control groups: Thomas et al. (2020), where the HVLA was compared to another technique (spinal mobilization) as well as a placebo sham cold laser (7), and Xia et al. (2016), which used another technique (Flexion-distraction) and a wait list control group (8).

Regarding the anatomical region where the HVLA technique was administered there was not much variance, and in virtually every study the thrust was applied to some segment of the spine. The only deviation from this was in Boff et al. (2020) and Xia et al. (2016), where the technique also could potentially also be applied to the SI-joint (2, 8)

There was a slight difference in primary outcome measures, however each and every article measured some aspect of pain reduction in one or multiple ways - primarily in the form of a numerical scale such as either VAS (2, 3, 8) or NPRS (1, 4, 6, 7), including an eventual assessment of PPT (1, 3, 4), or in one singular case assessed using the Penn Shoulder Score (5).

In terms of effectiveness, the HVLA technique showed a trend of significant, and occasionally also clinically important, outcomes for pain relief. It is worth noting however that the beneficial results for between-group comparisons were either insignificant or in one case, in favour of the control group (3). An exception to this was Xia et al. (2016) as its wait list control outcomes were significantly worse than the HVLA group. However, no significant difference was observed when the HVLA-T group was compared to the FD group (8)

Table 4 - Brief overview of included articles								
Author(s) (Study ref.)	Sample size (n)	Population	Sessions (n)	Data collection	Region of administration	Comparison	Pain assessed with	Results
Aspinall et al., 2019a (1)	80	Chronic Low Back Pain	1	Pre, post: immediate, 15min, 30min.	HVLA-T. Fifth lumbar vertebrae	Sham HVLA-T	PPT; NPRS	Significant improvements in immediate calf and shoulder PPT (P = .039 respectively p = .002), 30min hand TS (NPRS; p = .005) and all feet TS (NPRS; median p = 0.01). Between-group differences attributed to regression to the mean
Boff et al., 2020 (2)	72	Non-Specific Back Pain	6	Pre, post: 3w, 3m	HVLA-T. Sacroiliac and lumbar spine. Therapist selected the segment of administration.	HVLA-T, with added myofascial release	VAS	Significant improvements post intervention (p = 0.003). Returned to baseline at follow-up.
Carrasco-Martínez et al., 2019 (3)	150	Chronic Low Back Pain	4	Pre, post: after last session	HVLA-T. Lumbar spine, L3-L4 level	Flexion-Distraction technique	VAS; PPT	Significant improvements (p < 0.001). Comparison performed better.
García-Pérez-Juana et al., 2018 (4)	54	Chronic Mechanical Neck Pain	1	Pre, post: after intervention, 1w	HVLA-T. Midcervical segment (C3-C4). Two groups: Left or right.	Sham HVLA-T	PPT; NPRS	Significant improvements for PPT C5 to C6 level (p = .003) and tibialis anterior (p = .04). No improvement of pain intensity at 1w follow up.
Grimes et al., 2019 (5)	60	Subacromial Pain Syndrome	1	Pre, post: immediate, 48h	Between levels of C7-T4. Two groups: supine or seated	Sham HVLA-T	Penn Shoulder Score	No significant between-group differences (p = .549). No baseline for any pain factor presented.
Griswold et al., 2018 (6)	103	Mechanical Neck Pain	2	Pre, post: visit #2, discharge	Most symptomatic segment of cervical and thoracic spines.	Non-thrust manipulation	NPRS	Clinically important improvement of NPRS (>MCID). Comparison performed equivalently.
Thomas et al., 2020 (7)	162	Chronic Low Back Pain	6	Pre, post: 72h, 4w.	Spinous process of lumbar vertebrae	Spinal mobilization; Placebo (sham cold laser)	NPRS	MCID improvement 72h post, but not clinically important 4w post. No significant differences between groups.
Xia et al., 2016 (8)	192	Subacute and Chronic Low Back Pain	4	Pre, post: 3w	Fourth or fifth lumbar vertebrae, or sacroiliac joint	Non-thrust manipulation (Flexion-distraction); Wait list control	VAS	Both manipulation groups showed similar, but significant and clinically relevant, results (MCID) when compared to wait list control.

See Appendix A for more information about the studies included

4.4 Summary of individual articles

There was a total of five articles which included a population with low back pain. The first of these, Aspinall et al. (2019a), analysed 80 participants equally divided to either have received a HVLA-T directed at the lower back, or a sham HVLA-T. The sham had a similar positioning to the real HVLA-T, but included a "*slow, gentle, non-specific 'thrust'*" which was intended to mimic the real intervention. Pain was assessed using PPT and NPRS, and the primary outcomes were changes in PPT (lumbar spine, calf, and shoulder), and temporal summation (TS) (feet, and hands) – which was measured with the NPRS. A single treatment session took place, and measurements were taken at 4 different time points: Baseline, immediate, 15 min, 30 min. Within-group differences for HVLA-T showed significant results for immediate calf PPT ($p = .039$), immediate shoulder PPT ($p = .002$), 30 min hand TS ($p = .005$), as well as all measurements for feet TS (median $p = .011$). No significant differences between-groups, and eventual differences were attributed to regression to the mean. (1)

In the second of these low back articles, i.e., Boff et al. (2020), 72 participants attended 6 sessions where they either received a HVLA-T, or HVLA-T but with added myofascial release. Primary outcomes were disability, and pain intensity - which was evaluated using VAS presented as a 10cm line ranging from 0 ('*absence of pain*') to 10 ('*worst pain*'). The between-group comparisons showed no differences but within time-points analysis showed significant results ($p = .003$) post-intervention, but no significant differences ($p = 0.7$) at a 3-month follow-up. (2)

In the next article, Carrasco-Martínez et al. (2019), a sample of 150 patients suffering from chronic low back pain were randomly allocated to either receive flexion-distraction or a HVLA-T. The subjects attended 4 visits and the aim of the study was to compare the short-term effectiveness between these techniques. Pain was assessed using VAS and PPT and showed clinically important outcomes, however the flexion-distraction group performed better with statistically significant ($p < 0.001$) results in all outcome variables when compared to the HVLA-T group. (3)

The 2 remaining low back articles were similar in the sense that they both had 2 control groups. One of these was Thomas et al. (2020) which consisted of 162 participants who partook in 6 visits. During these visits they either received a HVLA-T, a spinal mobilization, or a placebo – in this case a sham cold laser (however, the clinicians were not aware that the laser was in fact a sham intervention). Primary outcomes were reduction of pain and disability, and pain was measured with NPRS. The change in baseline was significant for the HVLA-T group (p = .002) when measured 72h after treatment, however this effect was not sustained at a 4 week follow up (p = .49), and between-group comparisons for HVLA-T at the primary end point did not show any significant differences in term of pain scores whether compared to the mobilization group (p = .45) or the placebo laser group (p = .92). (7)

The last of the low back articles was Xia et al. (2016), which was the only group that included a *true* control group as one of the groups was a wait list control, and thus did not receive any intervention. In this article 192 participants were divided between a HVLA-T group or a non-thrust manipulation group (more specifically, flexion-distraction), which both received a total of 4 sessions, or the 2-week wait list control. The primary outcome was disability related to the low back pain, and the secondary outcome was low back pain intensity which was evaluated with VAS. Both manual interventions showed clinically important results in terms of pain relief when compared to the wait list control group, however there were not any significant differences between these groups and no p value was presented. (8)

Out of the remaining 5 articles, 2 consisted of populations with neck pain, and 1 with subacromial pain syndrome. The thrust, however, was applied in similar regions (i.e. Some segment of the thoracic or cervical spine).

In García-Pérrez-Juana et al. (2018), 54 participants with chronic mechanical neck pain received a cervical HVLA-T or a sham HVLA-T. The thrust was either administered on the right or left side at a mid-cervical level (C3-C4), and the sham procedure was administered in the same way, but with the thrusting force applied outside of the perceived tension. In the HVLA-T group the patient was not included in the analysis if no AP was heard, and in the sham group there was no AP at all. Primary outcome was cervical kinaesthetic sense assessed with joint position sense error (JPSE) and PPT. Pain was also assessed at week 1 with NPRS. All groups had a clinically important, albeit similar, decrease in neck pain intensity, and within the HVLA-T groups there were also significant hypoalgesic effects in PPT at the C5 to C6 level (p = .003) and tibialis anterior (p = .04). This was however not an effect which was sustained a week after the intervention. (4)

The other article which had a population with neck pain was Griswold et al. (2018), in which 103 participants were split up between two groups and either received a HVLA-T or a non-thrust manipulation. The region of administration was the most symptomatic segment of the cervical or thoracic spine and the intervention was applied in a pragmatic fashion. In the HVLA-T group the clinician would decide factors such as number of thrusts and direction of thrust, and in the non-thrust group the clinician would employ a *"graded oscillatory technique"* where the dosage was also up to the clinician. Primary outcomes were neck disability measured with The Neck Disability Index (NDI), and pain was a secondary outcome measured with NPRS. Clinically important results in terms of pain relief were obtained in both groups, however both groups received similar changes in pain and there was no significant difference (p = .25) when these were compared. (6)

Sticking out as the only article where the population did not suffer from any segmental (e.g., neck or back) pain was Grimes et al. (2019). Here there were 60 participants suffering from subacromial pain syndrome which were equally divided to either receive a seated or supine HVLA-T, or a sham HVLA-T performed in the same manner as the seated HVLA-T but without a manipulative thrust. Primary outcomes were pain, disability, and motor performance, which was assessed with the Penn Shoulder Score. The between-group comparisons did not show a significant result in terms of pain relief (p = .549), and no baseline value for pain intensity was specified - just the "*duration of pain"*. (5)

5 Discussion

5.1 Limitations of review

This review does have its limitations. For starters the reliability of the quality assessment as well as the evaluation of ethical considerations can be disputed as it was only assessed by one of the authors. Although the initial plan was for both authors to do it, personal life became an obstacle which meant this could not be completed. The author who did assess the articles, however, also had no prior experience of either the PEDro scale or the protocol used for ethical considerations. This meant, amongst other things, that one of the items in the ethics protocol was not assessed, and its validity should therefore be viewed with caution. There was also no assessment of bias. If that would have been investigated, as well as perhaps used as an inclusion criterion, it could have potentially increased the quality of included articles. Another limitation is also how there was no analysis or comparison of factors such as dosage of either the HVLA-T itself or treatment sessions in general.

Pain relief was not measured using one singular specific method, which is another limitation, as this comes with the hardships of translating the results between these. It might be to some extent between VAS and NPRS, however, they do have some similarities in that they (a) both are unidimensional scoring systems (Visual respectively numerical), and (b) both can measure intensity of pain, which also makes them more interchangeable. There is also some evidence which points towards a significant positive correlation between these (Shafshak and Elnemr, 2020). Comparing these with PPT proves more difficult as PPT requires external administration, and thus somewhat measures the tolerance to pain rather than the subjective current intensity experienced. Also, some research points towards PPT not correlating particularly much with VAS (Lau, Muthalib and Nosaka, 2013), and extrapolating from that, probably not NPRS either. The Penn Shoulder Score, used in one of the articles (5), uses the NPRS for scoring pain-related outcomes, so this proves less of a challenge to compare with the other results.

Heterogeneity of included articles also deserves to be pointed out. Thus, the results are deemed only applicable for a minor subgroup of people suffering from MSC. It is therefore not possible to evaluate if the effects seen would be the same in patients with other MSCs.

Added to the list of limitations is a general lack of specificity in terms of what was being reviewed - mainly regarding factors surrounding pain. By making clearer definitions, such as “immediate decrease in pain intensity post HVLA-T” (thus introducing the factor of timing), or by limiting the included articles by a specific tool of assessing pain (e.g. VAS), a more specific conclusion could possibly have been made.

The authors also note that they had hoped to see a larger number of articles where the HVLA was applied to a peripheral joint, and in hindsight a change of the search query to include specific joints or anatomical areas could have been made to achieve this.

5.2 Limitations of articles

Lack of blinding of therapists is the most notable observation that sticks out in every article, and while this is next to impossible with manual techniques, it is still important to address. Good attempts were made however, such as in Thomas et al. (2020) where the clinicians who administered the laser treatment were not aware that it was in fact a sham intervention.

There are also instances of excluding patients if the HVLA did not produce an AP, such as in García-Pérez-Juana et al. (2018). With the current evidence of the AP not being necessary for the technique, this deserves to be scrutinized.

In some of the articles a proper analysis of the data could not be performed. The authors could not locate a baseline value for pain in Grimes et al. (2019), and in Xia et al. (2016) no p-value could be found either. Albeit the authors do report that this could also be due to a lack of prior academic work on their end.

The different articles also approached the choice of where to administer the HVLA-T in different ways. In two articles (1, 4) the region was predetermined. In others, the therapist could adopt a more pragmatic approach and select where to administer the thrust based on hypomobility (2) or based on which region was most symptomatic (6). In some articles

(3, 7, 8) the choice of segment was not specified, but rather the technique to reach the desired patient position as well as thrust direction was described. In another article (5) the region was stated (between levels of C7-T4), but the clinical reasoning why that region was chosen was not presented, rather based on three other articles which all administered the HVLA-T in different ways. As mentioned in **1.4.1 Thrust Techniques**, it is not clear if this sort of specificity matters, however, even if it does matter or not, it still deserves to be brought up as it could be considered a limitation by some.

5.3 Discussion of results

The primary objective of this literature review was to review current scientific literature to evaluate the effectiveness of a HVLA-T on pain relief in MSCs, and while all articles included in this paper used the technique to treat some aspects of MSCs, they did not all have pain relief as a primary objective. However, every article included did measure it in some way as per the inclusion criteria.

Regarding the primary outcomes, the findings of this review show a trend for an overall positive effect in terms of pain relief. This effect was also in many cases clinically important and statistically significant. It is however important to note that the included RCTs did not show a large discrepancy in the between-group comparisons - regardless of alternative intervention. This was more or less the general trend in every study, but there were exceptions with Carrasco-Martínez et al. (2019), where the flexion-distraction intervention group had better results than the HVLA-T group, and in Xia et al. (2016). Unique to the latter article was a wait list control group, and this group ended up performing worse than both the other intervention groups.

A secondary outcome was to investigate if discrepancies of the proposed hypoalgesic effects exist depending on the anatomical region of where the HVLA-T was administered. This was also the main reason to keep the database search query broad and not incorporate terms pertaining to the spine, like for instance *SMT* or *Spinal Manipulation*, but yet each of the included RCTs applied the HVLA-T to some axial joint (spine and/or SI-joint). It is therefore not possible to properly evaluate if a peripheral HVLA is as effective as an axial HVLA in terms of pain relief, which the authors note were their primary intention with incorporating this research question, however the results from the articles that measured PPT do show a slight indication that the effects of a HVLA-T could possibly have a more global effect than just affecting the specific joint and/or tissue surrounding the joint to which the technique is being applied. However, the findings, albeit showing a positive trend, begs the question if the eventual hypoalgesic effects present in this review come as a result of the HVLA-T in itself (i.e., as a specific intervention), or if it is just a result from receiving an intervention at all.

Some potential factors for the changes seen in pain could be due to the Hawthorne Effect, where the mere observation of participants influence changes in their behaviour and performance, or via regression to the mean - which is pointed out in one of the articles (1). It is also worth considering to what extent the placebo effect influences the outcomes as well as factors such as the individual expectations of the patient receiving the intervention - both seeming to have a close-knit relationship with musculoskeletal pain and the management of it (Bialosky, Bishop and Cleland, 2010). However, due to the limitations of this review, a proper analysis of the factors causing the effects is a strenuous, and most likely impossible, task.

That is not to say that every outcome of HVLA-T is due to the Hawthorne effect or placebo as there are many possible effects of the technique, as well as manual therapy in general. Bialosky et al. (2009) proposed a model with five primary mechanisms which could possibly explain the effects of HVLA-T which range from the mere mechanical stimulus to the influence of spinal and supraspinal structures, as well as peripheral mechanisms. This model does have limitations, and it is also meant to include all forms of MT, and thus it is not unique for HVLA. However, these limitations of the model are addressed, and it is probably safe to assume that the neurophysiological responses are similar when different techniques are compared.

What the mechanisms behind the hypoalgesia seen in the included RCTs are due to is a difficult task, and only Grimes et al. (2019) mentions the term *mechanism* in their discussion. Here it is stated that the biomechanical factors are probably not the reason for the outcomes seen due to the between-group comparisons not differing in any substantial amount. Instead, the outcomes are attributed to non-specific factors (e.g., patient expectation, manual contact, and psychosocial). The effects seen in the other studies can also be due to this, and it is likely considering the lack of difference in comparisons, but this does not go to say that other mechanisms in the model presented by Bialosky are not at play.

Addressing the clinical implications of these results show two sides of the coin. For a clinician who is faced with results like the ones presented in this review, especially in terms of the lack of differences in the between-group comparisons and clear evidence for the mechanisms behind the scenes, it might seem difficult, if not also unethical, to justify the use of HVLA-T in clinical practice. It does not become easier when considering how pain is multifactorial, influenced by a multitude of factors (such as for instance biological, psychological, or environmental), and how pain can be highly variable in terms of intensity and severity through the span of disease (or even a lifetime). This does of course make it harder to ascertain if the hypoalgesic effects that might be experienced is due to the treatment, but it is still good to be open, as well as curious, to the potential clinical value the technique holds - which shows the other side of the argument.

Take for instance a person who suffers from pain associated with MSC, and that pain is the cause of a reduction in their QOL and an increase in disability. For this person the mechanisms through which an intervention produces its results might not be of high importance (if any) – as long as there is clinical improvement. Added to this is if the patient previously has experienced positive effects of HVLA-T.

This should not be misconstrued as an implication to not conduct further research in the field of thrust manipulation and its mechanisms – just a reminder to listen to and not disregard patient’s previous experiences and to, arguably, do this with a person-centred care (PCC) mindset. This could allow the patient to partake in the clinical process and make it more suitable for their beliefs, experiences, and preferences. In a scenario like this one could also be available to inform the patient what we do, and what we don’t know about the technique. Last, but certainly not least, it is important to note that pain (regardless of if it’s the result of a MSC or something else), and the management of it should take into account all these factors listed. A multifactorial issue often needs a multifaceted approach, and this is a place where osteopathy can shine with its holistic perspective. It is also important to make a proper risk assessment before administering a HVLA-T (or any intervention for that matter). This multifaceted approach to pain is one which does fall in line with osteopathy, as an osteopath should address the whole person and not just disease or condition which they are experiencing.

Summarizing the current state, and specifically during the time of writing, there is not much research conducted into the effectiveness of generalized pain-relief (independent of region where it is administered) achieved with the use of HVLA-T. For instance, a PubMed search, performed with the same search query used in this review, only yields 8 results when using *Meta-Analysis* as the sole filter - this is further reduced to 4 results when applying the same publishing date used in this review, and 3 out of these pertain to the spine or neck. There is only one of these articles which has a wider approach, similar to this review, and encompasses a broader population not limited by region. In this meta-analysis, changes in PPT were measured to investigate manipulation-induced hypoalgesia (MIH), i.e., *"[...] reduced pain sensitivity following joint manipulation"*, and the results pointed towards the existence of a systemic MIH being present post-intervention. However, just as in this current review, there were no significant differences in between-group comparisons, which even further begs the question if the physiological responses are due to the technique, or just non-specific effects. (Aspinall et al., 2019b).

The authors would like to end by stating that, while the title of this review is merely meant as a pun, the thrust does in fact not seem to be a must.

6 Conclusion

HVLA-T appears to be an effective manual technique in terms of pain-relief when administered to a subgroup of patients suffering from MSCs. However, when compared to other manual techniques there does not seem to be any significant differences in terms of outcomes for pain-relief. There is also slight evidence indicating that the technique not only can create local hypoalgesic effects, but potentially also have a more global effect regarding sensitivity to pain. However, further research is needed to confirm the mechanisms through which the practical administration of the technique produces its result. Other future research areas also include a comparison of HVLA-T to other treatment modalities in terms of effectiveness for pain-relief in MSCs, as well as research investigating potential differences for pain-relief in peripheral versus axial HVLA-T.

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Appendix A

This Appendix A presents the various tools such as (a) scales to measure pain and/or other outcomes, and (b) tools used assessment of quality or ethics. The tools labelled B1-B4 address the scales to measure pain/outcomes, while B5-B6 addresses the various assessment tool(s).

A1 – Numeric Pain Rating Scale (NPRS)

As mentioned in **1.3.2 Measuring Pain**, various iterations of the scale exist (for instance 11-, 21-, or 101-point scales). The scale can also have text under each of the different divisions, or just affixed to the ends. The scale presented in **Fig. A1** is a simple 11-point scale. See each respective article for information about which NPRS was used.

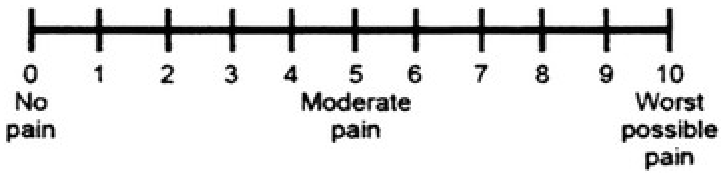

Fig. A1. Example of an 11-point Numeric Pain Rating Scale *(DrTrumpet, CC BY 4.0 <https://creativecommons.org/licenses/by/4.0>, via Wikimedia Commons)*

A2 – Penn Shoulder Score

PENN SHOULDER SCORE

Patient Name:		Date:
Address:		
City & State:		Zip code:
Home Phone:	Work Phone:	Age:
Dominant Hand:	Gender:	Affected Arm:
L R Both (circle one)	**M F** (circle one)	**L R Both** (circle one)

Since beginning therapy for your shoulder, would you say that your shoulder has:	
	Gotten much worse
	Gotten moderately worse
	Gotten slightly worse
	Stayed the same
	Gotten slightly better
	Gotten moderately better
	Gotten much better

PENN SHOULDER SCORE **Part I: Pain & Satisfaction:** Please circle the number closest to your level of pain or satisfaction	office use only
Pain at rest with your arm by your side: 0 1 2 3 4 5 6 7 8 9 10 No Pain … Worst Pain Possible	____ (10 - # circled)
Pain with normal activities (eating, dressing, bathing): 0 1 2 3 4 5 6 7 8 9 10 No Pain … Worst Pain Possible	____ (10 - # circled) (mark X if not applicable)
Pain with strenuous activities (reaching, lifting, pushing, pulling, throwing): 0 1 2 3 4 5 6 7 8 9 10 No Pain … Worst Pain Possible	____ (10 - # circled) (mark X if not applicable)
PAIN SCORE:	**=___/30**
How satisfied are you with the current level of function of your shoulder? 0 1 2 3 4 5 6 7 8 9 10 Not Satisfied … Very Satisfied	**=___/10** (# circled)

PLEASE TURN OVER TO COMPLETE QUESTIONNAIRE

OFFICE USE ONLY

PENN SHOULDER SCORE		
Visit Date	**Last visit** __/__/__	**Today** __/__/__
Pain	/30	/30
Satisfaction	/10	/10
Function	/60	/60
TOTAL	/100	/100

Appendix A

PENN SHOULDER SCORE Part II: Function: Please circle the number that best describes the level of difficulty you might have performing each activity.	No difficulty	Some difficulty	Much difficulty	Can't do at all	Did not do before injury
1. Reach the small of your back to tuck in your shirt with your hand.	3	2	1	0	X
2. Wash the middle of your back/hook bra.	3	2	1	0	X
3. Perform necessary toileting activities.	3	2	1	0	X
4. Wash the back of opposite shoulder.	3	2	1	0	X
5. Comb hair.	3	2	1	0	X
6. Place hand behind head with elbow held straight out to the side.	3	2	1	0	X
7. Dress self (including put on coat and pull shirt of overhead.	3	2	1	0	X
8. Sleep on affected side.	3	2	1	0	X
9. Open a door with affected side.	3	2	1	0	X
10. Carry a bag of groceries with affected arm.	3	2	1	0	X
11. Carry a briefcase/small suitcase with affected arm.	3	2	1	0	X
12. Place a soup can (1-2 lbs.) on a shelf at shoulder level without bending elbow.	3	2	1	0	X
13. Place a one gallon container (8-10 lbs.) on a shelf at shoulder level without bending elbow.	3	2	1	0	X
14. Reach a shelf above your head without bending your elbow.	3	2	1	0	X
15. Place a soup can (1-2 lbs.) on a shelf overhead without bending your elbow.	3	2	1	0	X
16. Place a one gallon container (8-10 lbs.) on a shelf overhead without bending your elbow.	3	2	1	0	X
17. Perform usual sport/hobby.	3	2	1	0	X
18. Perform household chores (cleaning, laundry, cooking).	3	2	1	0	X
19. Throw overhand/swim/overhead racquet sports (circle all that apply to you)	3	2	1	0	X
20. Work full-time at your regular job.	3	2	1	0	X
SCORING: Total of columns = _____ (a) Number of "X's" x 3 =____(b), 60 – ___(b) = ____ (c) (If no "X's" are circled, function score = total of columns) Function Score = ___(a) ÷ ___(c) = ___ x 60 = _____ of 60					

A3 – Pain Pressure Threshold (PPT)

See **Fig. A2.** for an example of measuring PPT using an algometer. As noted in **1.3.2** there exists no standardized protocol for measuring PPT - this includes the choice of algometer, however the studies usually present which type, as well as brand, of algometer is used for the measurements.

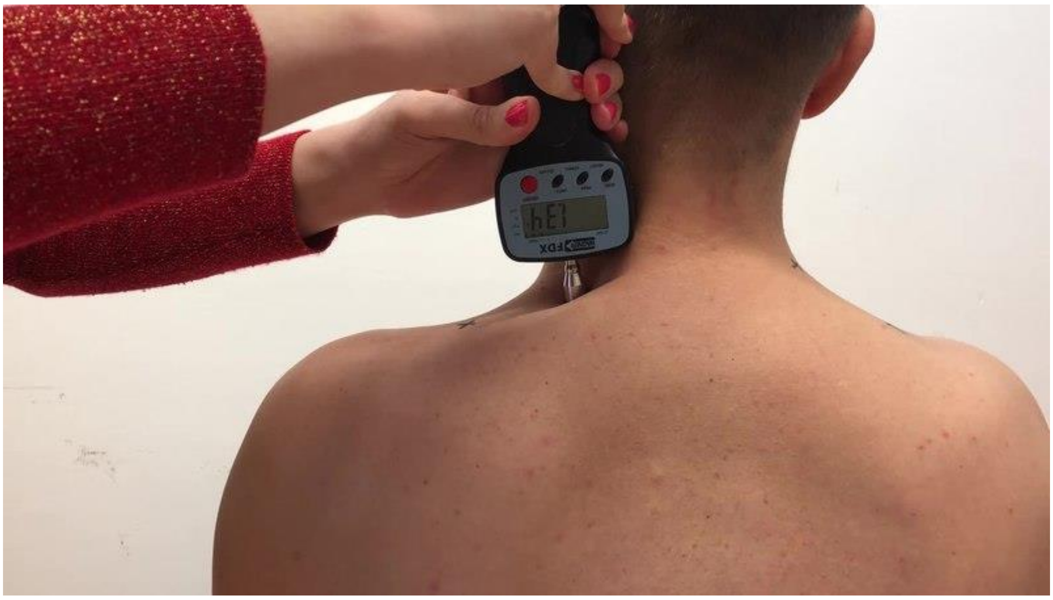

Fig. A2 Example of a PPT measurement using an algometer. (DrTrumpet, CC BY 4.0 <https://creativecommons.org/licenses/by/4.0>, via Wikimedia Commons)

See each respective article for information about how PPT was assessed.

A4 – Visual Analogue Scale (VAS)

Note that various iterations of the scale exist. The scale can for instance have subdivisions (e.g., “Moderate pain” in the centre), or even be presented with illustrations of faces appearing happy if no pain is present, or in distress if it is the worst pain imaginable.

Fig. A3 Simple iteration of VAS scale

The scale presented in **Fig. A3.** is one of the simpler forms of the scale created by the authors for the sake of presentation. However, the scale is not created with any regard to proper scale. When presented on printed paper it is important to make sure that the printed copy provides correct dimensions as this can differ depending on, for example, the printer used.

See each respective article for information about how the VAS was presented.

A5 – PEDro Scale

PEDro scale

1.	eligibility criteria were specified	no ❑ yes ❑ where:
2.	subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	no ❑ yes ❑ where:
3.	allocation was concealed	no ❑ yes ❑ where:
4.	the groups were similar at baseline regarding the most important prognostic indicators	no ❑ yes ❑ where:
5.	there was blinding of all subjects	no ❑ yes ❑ where:
6.	there was blinding of all therapists who administered the therapy	no ❑ yes ❑ where:
7.	there was blinding of all assessors who measured at least one key outcome	no ❑ yes ❑ where:
8.	measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	no ❑ yes ❑ where:
9.	all subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat"	no ❑ yes ❑ where:
10.	the results of between-group statistical comparisons are reported for at least one key outcome	no ❑ yes ❑ where:
11.	the study provides both point measures and measures of variability for at least one key outcome	no ❑ yes ❑ where:

The PEDro scale is based on the Delphi list developed by Verhagen and colleagues at the Department of Epidemiology, University of Maastricht (*Verhagen AP et al (1998). The Delphi list: a criteria list for quality assessment of randomised clinical trials for conducting systematic reviews developed by Delphi consensus. Journal of Clinical Epidemiology, 51(12):1235-41*). The list is based on "expert consensus" not, for the most part, on empirical data. Two additional items not on the Delphi list (PEDro scale items 8 and 10) have been included in the PEDro scale. As more empirical data comes to hand it may become possible to "weight" scale items so that the PEDro score reflects the importance of individual scale items.

The purpose of the PEDro scale is to help the users of the PEDro database rapidly identify which of the known or suspected randomised clinical trials (ie RCTs or CCTs) archived on the PEDro database are likely to be internally valid (criteria 2-9), and could have sufficient statistical information to make their results interpretable (criteria 10-11). An additional criterion (criterion 1) that relates to the external validity (or "generalisability" or "applicability" of the trial) has been retained so that the Delphi list is complete, but this criterion will not be used to calculate the PEDro score reported on the PEDro web site.

The PEDro scale should not be used as a measure of the "validity" of a study's conclusions. In particular, we caution users of the PEDro scale that studies which show significant treatment effects and which score highly on the PEDro scale do not necessarily provide evidence that the treatment is clinically useful. Additional considerations include whether the treatment effect was big enough to be clinically worthwhile, whether the positive effects of the treatment outweigh its negative effects, and the cost-effectiveness of the treatment. The scale should not be used to compare the "quality" of trials performed in different areas of therapy, primarily because it is not possible to satisfy all scale items in some areas of physiotherapy practice.

Last amended June 21st, 1999

A6 – Protocol for Ethics Assessment

The protocol used for ethical assessment in this literature review is taken from Weingarten, Paul and Leibovici (2004). It is divided into 4 different areas and constitutes 10 items. See **Table A1** for a slightly modified version of the original protocol presented in the article

Table A1. Ethical assessment protocol (Weingarten, Paul and Leibovici, 2004)

Goal related considerations	(1) Clear declaration on financial support in all trials? (2) Statement that relates to potential conflicts of interest in all trials. (3) Justification – Was the size of the study sufficient to achieve adequate statistical power? (4) Publication bias – How many of the identified trials remained unpublished? Is bias detectable by funnel plot analysis?
Duty related considerations	(5) Appropriate comparators? If a placebo, was it justified?
Rights related considerations	(6) Safety – Risk/reward appropriate to the importance of the research? Appropriate follow-up care assured? (7) Informed consent obtained? (8) If participants had reduced competence, were appropriate measures taken to protect their best interests? (9) Adequate steps taken to guarantee patient and clinic confidentiality and privacy
Global considerations	(10) Was the study approved by a research ethics committee?

Appendix B

This Appendix B presents the articles included in this literature review. Articles are labelled A1 through A8 in alphabetical ascending order, sorted after the first author's surname.

B1 – Aspinall et al., 2019

Title	No difference in pressure pain threshold and temporal summation after lumbar spinal manipulation compared to sham: A randomised controlled trial in adults with low back pain
Author(s)	Sasha L. Aspinall, Angela Jacques, Charlotte Leboeuf-Yde, Sarah J. Etherington, Bruce F. Walker
Objective	Compare short term changes in PPT and TS (Measured with NPRS, 0-100) between (A) lumbar HVLA-T and a (B) sham manipulation in people with low back pain.
Method	Double-blind randomized control study. Primary outcomes were PPT (Calf, lumbar spine, shoulder) and TS (Hands, feet) measured at baseline, immediate, 15min, 30min.
Result	80 participants divided equally (40/40). PPT and TS, Within-group adjusted difference (immediate, 15min, 30min). Presented as p-value (p < .05; CI = 95%): PPT, A: Calf (.039, .118, .756); Lumbar (.367, .128, .776); Shoulder (.002, .317, .294). PPT, B: Calf (.003, .020, .066); Lumbar (.056, .367, .499); Shoulder (.008, .056, .152). TS, A: Hand (.737, .279, .005); Feet (.014, .011, .007). TS, B: Hand (.895, .251, .006); Feet (.122, <.001, <.001).
Conclusion	Lumbar SMT did not lead to greater short-term changes in PPT compared to sham manipulation in people with LBP. Suggests that HVLA-T does not have a specific hypoalgesic effect.

B2 – Boff et al., 2020

Title	Effectiveness of spinal manipulation and myofascial release compared with spinal manipulation alone on health-related outcomes in individuals with non-specific low back pain: randomized controlled trial
Author(s)	Taise Angeli Boff, Fernanda Pasinato, Angela Jornada Ben, Judith E. Bosmans, Maurits van Tulder, Rodrigo Luiz Carregaro
Objective	Compare (A) HVLA-T, with (B) HVLA-T + Myofascial Release, in individuals with chronic non-specific low back pain (CNLBP).
Method	Randomized Control Trial with three-month follow-up. Primary outcomes were disability (using Quebec Back Pain Questionnaire), and pain intensity evaluated with VAS (10cm, 0 — absence of pain, 10 — worst pain).
Result	72 participants divided equally (36/36). No difference between-groups so A and B were combined for within time-point analysis which showed post intervention p value = .003, and follow up p value = 0.7 Significant results were also showed in the AB-combined within time-point analysis for disability post-intervention but not at follow up (p < .001 respectively p = .2)
Conclusion	Myofascial release added to HVLA-T does not produce extra benefit for pain intensity or disability in individuals with CNLBP. Short-term improvements, but no retention effect after 3 months.

B3 – Carrasco-Martínez et al., 2019

Title	Short-term effectiveness of the flexion-distraction technique in comparison with high-velocity vertebral manipulation in patients suffering from low-back pain
Author(s)	Francisco Carrasco-Martínez, Alfonso Javier Ibáñez-Vera, Antonio Martínez-Amat, Fidel Hita-Contreras, Rafael Lomas-Vega
Objective	Compare short-term effects of (A) HVLA-T with (B) FD, in individuals with chronic low back pain (CLBP).
Method	Assessor-blind Randomized Control. Primary outcomes were pain measured with VAS and PPT. Also, various other tests for disability and ROM.
Result	150 participants divided equally (75/5). Data presented as follows: Mean VAS (pre/post), mean average PPT (pre/post) A: VAS (6.04/4.45), PPT (4.97/5.44) B: VAS (5.91/3.03), PPT (4.72/5.81) Significant between-group differences in favour of FD ($p < 0.001$). Clinically important VAS reductions for both intervention groups.
Conclusion	Beneficial effects of FD technique in comparison to HVLA-T were clinically and statistically significant.

B4 – García-Pérez-Juana et al., 2018

Title	Changes in Cervicocephalic Kinesthetic Sensibility, Widespread Pressure Pain Sensitivity, and Neck Pain After Cervical Thrust Manipulation in Patients With Chronic Mechanical Neck Pain: A Randomized Clinical Trial
Author(s)	Daniel García-Pérez-Juana, César Fernández-de-las-Peñas, José L. Arias-Buría, Joshua A. Cleland, Gustavo Plaza-Manzano, and Ricardo Ortega-Santiago
Objective	Compare (A) Cervical HVLA-T (two sub-groups: left/right side; counted as one in this Appendix) with (B) sham manipulation in people with mechanical neck pain
Method	Single-blinded randomized control trial. Primary outcomes were immediate changes in cervical kinesthetic sense (assessed with joint position sense error). Secondary outcomes were immediate PPT changes, pain intensity after 1 week (NPRS) and neck-related disability (Neck Disability Index)
Result	54 participants divided as A: (18/18), B: 18 Significant improvements for PPT C5 to C6 level ($p = .003$) and tibialis anterior ($p = .04$) when A was compared to B. No improvement of pain intensity at 1w follow up.
Conclusion	Cervical HVLA-T does not improve neck pain intensity at 1 week follow-up. It does however improve JPSE, PPT and NDI in patients with chronic mechanical neck pain.

B5 – Grimes, Puentedura, Cheng and Seitz, 2019

Title	The Comparative Effects of Upper Thoracic Spine Thrust Manipulation Techniques in Individuals With Subacromial Pain Syndrome: A Randomized Clinical Trial
Author(s)	Jason K. Grimes, Emilio J. Puentedura, M. Samuel Cheng, Amee L. Seitz
Objective	Compare immediate effects of (A) supine thoracic HVLA-T, (B) seated thoracic HVLA-T, and (C) sham HVLA-T in patients with subacromial pain syndrome
Method	Randomized control trial. Primary outcomes were pain, function, and satisfaction which were all assessed with the Penn Shoulder Score
Result	60 participants, divided equally among the three groups (A: 30/B: 30/C: 30). No significant differences in between-group comparisons: Pain (p = .549); Function (p = .427); Satisfaction (p = .315) No baseline values were presented for the Penn Shoulder Score.
Conclusion	Neither seated nor supine thoracic HVLA-T had any superior effect on the measured outcomes when compared to a sham HVLA-T. Non-mechanical effects of manual therapy warrant further investigation

B6 – Griswold et al., 2018

Title	Pragmatically Applied Cervical and Thoracic Nonthrust Manipulation Versus Thrust Manipulation for Patients With Mechanical Neck Pain: A Multicenter Randomized Clinical Trial
Author(s)	David Griswold, Ken Learman, Morey J. Kolber, Bryan O'Halloran, Joshua A. Cleland.
Objective	Compare the clinical effectiveness of (A) HVLA-T, and (B) Non-thrust manipulation in patients with mechanical neck pain.
Method	Randomized control trial. Primary outcomes were neck disability index (NDI). Secondary outcomes included Patient-Specific Functional Scale (PSFS), numeric pain rating scale (NPRS), and two others (see article).
Result	103 patients analysed. Not split equal between groups (A: 48/B: 55) No between-group differences in any of the outcomes (NDI, p = .67; PSFS, p = .26; NPRS, p = .25) Clinically important outcomes in NPRS and NDI.
Conclusion	Both HVLA-T and non-thrust manipulation produce comparable outcomes on pain, disability, and motor performance for patients with mechanical neck pain when applied in pragmatic fashion.

B7 – Thomas et al., 2020

Title	Effect of Spinal Manipulative and Mobilization Therapies in Young Adults With Mild to Moderate Chronic Low Back Pain A Randomized Clinical Trial
Author(s)	James S. Thomas, Brian C. Clark, David W. Russ, Christopher R. France, Robert Ploutz-Snyder, Daniel M. Corcos.
Objective	Investigate and compare effectiveness of (A) spinal HVLA-T, (B) spinal mobilization, and (C) placebo (sham cold laser) in young adults with chronic low back pain.
Method	Investigator blinded placebo controlled randomized clinical trial. Primary outcomes were baseline changes in NPRS over last 7 days, and disability (Assessed with Roland-Morris Disability Questionnaire).
Result	162 patients randomized equally between groups (A: 54; B: 54; C: 54). At primary endpoint there were no significant differences in NPRS between A-B (0.24; 95% CI, -0.38 to 0.86; P = .45), A-C (-0.03; 95% CI, -0.65 to 0.59; P = .92), or B-C (-0.26; 95% CI, -0.38 to 0.85; P = .39). No significant differences were observed in terms of self-reported disability either. Significant result for 72h change in NRPS for A (p = .002) but not for B (p = .18)
Conclusion	Spinal HVLA-T and spinal mobilization are no more effective than a well-chosen placebo for reducing pain and disability in patients with chronic low back pain.

B8 – Xia et al., 2019

Title	Similar Effects of Thrust and Non-Thrust Spinal Manipulation Found in Adults With Subacute and Chronic Low Back Pain — A Controlled Trial with Adaptive Allocation
Author(s)	Ting Xia, PhDa, Cynthia R. Long, Maruti R. Gudavalli, David G. Wilder, Robert D. Vining, Robert M. Rowell, William R. Reed, James W. DeVocht, Christine M. Goertz, Edward F. Owens Jr., and William C. Meeker-
Objective	Compare short-term effects of (A) spinal HVLA-T, (B) non-thrust flexion-distraction technique, and (C) wait list control group, in adults with subacute OR chronic low back pain.
Method	Three-arm randomized control trial. Primary outcomes were low back pain-related disability (Roland-Morris disability questionnaire [RMDQ]) and secondary outcomes were LBP intensity (VAS), Fear-Avoidance Beliefs Questionnaire (FABQ), and 36-Item Short Form Health Survey (SF-36).
Result	192 participants divided unequally into the three groups (A: 72, B: 72, C: 48). Adjusted mean RMDQ and pain intensity (VAS) were no different between A-B at week 3 (RMDQ: 0 (-1.4, 1.5); VAS: -4.2 (-15.5 to 5.0), however both groups had significantly lower score than C (A-C, RMDQ: -3.0 (-4.7 to -1.4), VAS: -17.1 (-27.5 to -6.7); B-C, RMDQ: -3.1 (-4.8 to -1.4), VAS: -12.8 (-23.1 to -2.6)). Similar patterns seen in both FABQ and SF-36.
Conclusion	HVLA-T and non-thrust FD demonstrated similar effects in short-term LBP improvements, and both were clinically superior to a wait list control group.