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The Role of Osteopathic Practice in Multimodal Osteoarthritis Care of the Hip or Knee

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Abstract

BACKGROUND: Osteoarthritis (OA) is the second most prevalent cause of Musculoskeletal disorders, affecting 343 million people across the globe. Despite the nearly 50 non-pharmacological treatment modalities presented today, the research available, at present, omits incorporating osteopathic treatments into research protocols, and fails to contribute with evidence showing if treatments presented enhance the general effectiveness of rehabilitation in decreasing pain and disability in patients subjected to OA.

METHODS: A literature review based on searches in the following databases: CINAHL, COCHRANE, OVID and PubMed were conducted. All data was processed by the authors independently and subsequently agreed on in terms of relevance for the objectives of the review.

RESULT: Ultimately seven articles published between 2004 to 2018 were assessed. Three studies aimed to investigate interventions for OA of the knee alone, three involved both the osteoarthritic hip and knee, while one studied OA of the hip exclusively, but the main focus area remained the same, measuring pain severity and physical function. Six of them were randomized controlled trials, while one of them was a longitudinal study.

CONCLUSION: Research suggests that OMT can have a beneficial effect in the management of hip and knee OA, however, the presence of osteopathic interventions is as of today very poor in research available and further research is needed to determine the effects of OMT in multimodal clinical practice.

Keywords	Osteopathy, Osteoarthritis, Multimodal, Multidisciplinary, Manual Therapy, Hip, Knee

Contents

1. Introduction 5

1.1 Background 6
1.1.1 Osteoarthritis 6
1.1.1.1 Hip and Knee osteoarthritis 7
1.1.2 Manual therapy 7
1.1.3 Osteopathy 8
1.1.4 Manual therapies and osteoarthritis 9
1.1.4.1 Osteopathy and osteoarthritis 9
1.1.5 Multimodal care 10
1.1.5.1 Multimodal care and osteoarthritis 10

2. Problem statement 11

2.1 Leading question 12

3. Methodology 13

3.1 Literature research 14
3.2 Inclusion and exclusion criteria 15
3.2.1 Ethical consideration 16

4. Results 16

4.1 Outcome measures 18
4.2 Intervention protocol 19
4.3 Clinical outcome 22

5. Discussion 25

5.1 Limitations 34

6. Conclusion 34

References 35

List of abbreviations **1**

Appendices

Appendix 1. Abbreviations

1. Introduction

Musculoskeletal disorders (MSD) cover more than 150 conditions affecting the musculoskeletal system, ranging from short-term ailments like fractures, sprains and strains, to chronic conditions leading to long-termed limitations and disability of musculoskeletal function. MSD are commonly characterised by persistent pain and limitations in mobility, functional ability, and an overall decrease in quality of life (QOA), affecting the person's daily life and ability to work. The World Health Organization (WHO) declare an estimation of 1.71 billion people suffering from MSD worldwide, with osteoarthritis being the second most prevalent cause affecting 343 million people across the globe (WHO, 2021).

MSD contribute to substantial societal costs and accounted for more than 102 billion SEK in total costs in Sweden 2012, placing high demands on the national economy and primary care (Ahlberg, 2012). The costs are expected to continue increasing during the decades ahead due to higher mean lifespan (Ahlberg, 2012), and for this reason it is of high importance that future research support optimal treatment solutions that can aid the decrease in societal costs and healthcare load.

Several osteoarthritis treatment modalities of non-pharmacological, pharmacological and surgical interventions have been described during the last decades in medical literature and integrated in clinical guidelines (Barten et al., 2015), and manual therapy (MT) is often integrated with curative training in clinical practice when treating osteoarthritis (Abbott et al., 2015). Osteopathic manipulative treatment (OMT) is a division within MT that sets out to work with MSD and chronic conditions like OA by reducing pain, modulating perception of pain, restoring physiological function and increasing quality and range of motion (ROM), while providing the individualized treatment plan that many patients seem to be missing from primary care (Kuchera, 2007).

Despite the nearly 50 non-pharmacological treatment modalities presented today, the research available to date lacks incorporating osteopathic techniques into research

treatment protocols and fails to contribute with evidence showing if treatments presented might enhance the general efficiency of treatment in decreasing pain and impairment in patients subjected to osteoarthritis (Abbott et al., 2015).

1.1 Background

1.1.1 Osteoarthritis

Osteoarthritis (OA) belongs to the family of MSD and is considered a chronic degenerative disease, affecting the articular cartilage of the joint and the adjacent subchondral bone and synovium. OA may also result in new bone formation, such as osteophytes (Dieppe and Lohmander, 2005), and the change in tissue can evoke pain in the joint, stiffness, reduced ROM, crepitus, local inflammation and limited function (Woolf and Pfleger, 2003; Glyn-Jones et al., 2015; Licciardone et al., 2004). As of today, it is the most common joint disease with an estimation of 18 % female and 10 % male patients over 60 years of age influenced (Woolf and Pfleger, 2003).

The OA itself is a radiological finding that can be completely asymptomatic (Heidari, 2011). The tissue damage however is irreversible, and when it becomes symptomatic few treatments are effective. Yet, there are possibilities of achieving hypoalgesic effects and an increase in ROM with treatment, and potentially even delaying the progress of the disease (Felson, 2009; Vögele and Prodinger, 2019). OA may influence additional aspects of a patient's life that may cause further physical disability, such as inability to bend, lift or grasp objects (Cameron, 2002). These restrictions may alter various activities of daily life and lead to psychosociological isolation affecting work, hobbies, and other necessary ways of living (Cameron, 2002).

The predisposition for getting OA in one or multiple joints increases with age (Palazzo et al., 2016). Other factors include gender, obesity, trauma, overuse, and there also seems to be a hereditary factor (Jordan et al., 2003).

1.1.1.1 **Hip and knee osteoarthritis**

Both the hip and knee belong to the most common joints where OA is found in the body, both being put under heavy workload considering their weight bearing function in the lower extremity. This entails difficulties in loading off these joints. In conformity with OA in general, women seem to be affected by hip and knee OA to a higher degree, running a higher risk of developing adverse symptoms than men, especially in the knee. In addition the progression of OA in women is often worse (Turkiewicz, 2016).

Hip or knee OA is of today the most prevalent indication for the need of total hip- or knee replacement surgery (Zhang and Jordan, 2010), and approximately 10-20 % of patients with OA in one of these two joints ultimately need arthroplasty due to the poor reduction of its symptomatic manifestation, not receiving sufficient pain reduction nor change in functional ability (Turkiewicz, 2016). In the Better Management of Patients with Osteoarthritis (BOA) register's annual report from 2013, it was demonstrated that self-management of symptomatic hip OA was harder to receive good outcomes from than symptomatic knee OA. Furthermore, it showed that patients with hip OA had more problems with gait than patients with knee OA due to additional dysfunctions from other sites in the body than the affected joint, which indicates that other potential medical conditions are more present in hip OA than knee OA (The BOA-register, 2013).

Hip and knee OA cause substantial global medical and non-medical costs (Salmon et al., 2016), with the total amount of patients being diagnosed world-wide increased by 48 % from 1990 to 2019 (Hunter, March and Chew, 2020). In 2017, the number of patients diagnosed with hip and knee OA exceeded 300 million worldwide, a number foreseen to increase even further with the years ahead. According to the data published, women are yet again more susceptible than men (Safiri et al., 2020).

1.1.2 **Manual Therapy**

Manual therapy (MT) includes a wide range of techniques set out to primarily treat musculoskeletal pain and dysfunctions (Abbott et al. 2012) and has been defined as:

> *"[...] skilled hand movements intended to improve tissue extensibility; increase range of motion; induce relaxation; mobilize or manipulate soft tissue and joints; modulate pain; and reduce soft tissue swelling, inflammation, or restriction."* (IFOMPT, 2016)

These interventions aim to reduce adverse effects and symptoms deriving from MSDs, and adjust conditions such as ROM of the affected joint and associated myofascial structures, and is often performed by chiropractors, naprapaths, osteopaths, massage therapists, physiotherapists and other fields of physical expertise (French et al., 2011).

1.1.3 **Osteopathy**

Osteopathy was established as a health discipline with a "whole-person" perspective in the late 1800s by the American physician and surgeon Andrew Taylor Still. Over the course of time it has developed into two principal limbs, differentiating in-between a European tradition and an American tradition. American osteopathy is a part of the conventional medical field, where a medical student may have the option of studying to become an osteopathic physician (Doctor of Osteopathy; DO), whereas European osteopathy is part of a self-governing treatment discipline, separated from the conventional, physician controlled medical system (Bjerså, 2012). The European Standard on Osteopathic Healthcare Provision has defined the practice as follows:

> *"Osteopathy is a primary contact and patient-centered healthcare discipline, that emphasises the interrelationship of structure and function of the body, facilitates the body's innate ability to heal itself, and supports a whole-person approach to all aspects of health and healthy development, principally by the practice of manual treatment."* (Swedish Standards Institute [SIS], 2015)

The discipline incorporates osteopathic expertise, which includes various MT techniques, with up to date research into practice, a conclusive aspiration of improving all health related features of the body's structures, functions and ontogenesis. In difference from a medical physician that concentrates on pathological processes, an osteopath focuses on diagnosing, treating and alleviating dysfunctional manifestations

(Description of Osteopathy | EFFO, 2021). According to the European Committee for Standardization (CEN), the following manual therapy interventions are known to be part of osteopathic practice; high velocity-low amplitude-thrust, articulatory techniques, recoil techniques, soft tissue techniques, muscle energy techniques (MET), general osteopathic treatment, functional technique, strain-counterstrain, facilitated positional release, balanced ligamentous tension (BLT), ligamentous articulatory strain, myofascial release, fascial unwinding, myotensive techniques, Still technique, exaggeration techniques, cranial techniques, visceral and neural mobilisation, Chapman's reflexes, trigger points, neuromuscular techniques, lymphatic and visceral pump techniques (CEN, 2014).

1.1.4 **Manual therapies and osteoarthritis**

Management of OA per usual comprise pharmacologic treatment and/or some form of exercise therapy or physiotherapy, yet little attention has been placed on other manual therapeutic interventions, osteopathy included (Pollard et al., 2008). There are studies however that have shown that a multidisciplinary concept that incorporates manual therapy is potent in OA management (Pollard et al., 2008).

The American College of Rheumatology and the European League Against Rheumatism suggest physiotherapy, a non-pharmaceutical treatment method for OA that includes various treatment procedures like exercising, MT, knee taping, and education, to broadcast propositions of a self-management approach.

1.1.4.1 **Osteopathy and osteoarthritis**

Despite osteopathy being mentioned in a few studies it seems that most multimodal approaches omit osteopathy as an option of therapeutic intervention. It has been suggested that osteopathic manipulative treatment (OMT) might have hypoalgesic effects on OA, improve quality of ambulation and have a positive effect on rehabilitation of patients undergoing surgery (Castaño Betancourt, 2015). OMT and other manual therapeutic interventions can be of importance in a nonoperative treatment plan or a pre-/postoperative treatment plan in order to increase the QOL of patients suffering from adverse effects of OA (Altinbilek, 2018). In one study by Jordan et al. 2003, osteopathy is included in the multimodal approach towards treating OA, however this

meant that only 4.5 % of their patient group used osteopathy as a complementary treatment. Overall, the presence of osteopathic techniques in the management of OA is as of today very poor, this despite the plentiful protocols incorporating MT in clinical practice (Abbott et al., 2015).

1.1.5 **Multimodal care**

The clinical management of multimodal care incorporates multiple interventions in order to attend to symptoms and adverse effects of patients with a disability or pathological process (Sutton et al., 2014). Common modalities include self-management, patient education, pharmacological, psychological, physical, or restorative therapies, and sometimes MT.

The hypothesis of why chronic pain might require combined care is that chronic pain is a complex state where social and psychological factors interact closely with that of neurological and biomechanical factors which might indicate that the care must treat the condition on multiple levels (Peterson et al., 2018).

1.1.5.1 **Multimodal care and osteoarthritis**

Although there is no cure for OA, the treatments available set out to decrease symptomatic adverse effects and prevent the disease from evolving (Felson, 2009; Vögele and Prodinger, 2019; Hunter, 2011). The primary non-pharmacological treatments for OA include education to improve the knowledge of the condition and its management, exercise and MT, weight loss and bracing/joint support when needed with the aim of alleviating symptoms and maintaining physical fitness (Turkiewicz, 2016).

Treatments available in practice seem to vary, yet many study protocols mention a standardized multimodal approach consisting of physiotherapy, diet, exercise and education on OA (Miller et al., 2013). In some reports, other treatments that are often suggested include weight control, pharmacologic management of pain, and surgery (Roos and Juhl, 2012). Less recurrent modes of treatment and practitioners being presented include occupational therapy (OT), orthopaedic specialist, general practitioners and nurses (Hopman-Rock & Westhoff, 2000; van Baar et al., 2001;

Rosemann et al., 2007; Hansson et al., 2010), non-steroidal anti-inflammatory drugs (NSAIDs) chiropractors (Jordan et al., 2004), MEDIC-treatment, insoles (Thougaard Skou et al., 2012; Bennell et al., 2010). Furthermore, reports are presented of multimodal approaches with treatments such as aerobic training, ROM-exercises, joint articulation (non-thrust), and various injections, such as hyaluronic acid injections (Miller et al., 2013).

2. Problem statement

OA is today one of the most important global causes of disability in western populations and the annual costs attributable to OA are immense (Jordan et al., 2003). Furthermore, a huge part of the population affected can't seem to find relief from the pain nor improvement in symptoms, regardless of the almost 50 modalities of medical and non-medical procedures that are used to treat OA as described in the medical literature (Zhang et al., 2008). Despite the demonstrable burden of OA, the true development of the disease continues to be poorly understood and there is yet paucity of literature assessing the effects of MT-techniques as ways of treating symptomatic knee and hip OA (Pollard et al., 2008; Lalit et al., 2012).

The Institute of Medicine's Committee on Advancing Pain Research, Care and Education demonstrate that a lack of reimbursements and brief medical appointments oftentimes present with insufficient time and resources for an optimal treatment plan, incorporating a multidisciplinary approach, supervision of conditions and progression, patient education and exercise activities (Peterson et al. 2018). The economic aspects and time consuming nature of multimodal care, built on the idea that one patient alone should seek help within multiple fields instead of one, must also be kept in mind as a possible impediment when incorporating multidisciplinary interventions into the logistic challenge in real-world situations for the normal population.

Another important factor to emphasize is that research reveals that radiological findings are not factual causes of pain or physical ailments, even though they are often interpreted that way. The assessment of OA based on radiological findings is inadequate in its power to steer the management of OA, leading to more subjective measures of pain and disability guiding clinical practice (Pollard et al., 2008).

Furthermore, because of its slowly progressing nature, many patients bypass receiving medical care whilst patients that do inquire medical treatment are at many times inaccurately diagnosed or managed below standard, thus not receiving the treatment appropriate for their symptoms (Marra et al., 2012). These factors may contribute to an overall paltry experience of health management, potentially preventing patients from seeking care and thus denying them otherwise accessible means of education, medical support and treatment.

Could it be that the lack of initiating early staged diagnosis, combining multiple interventions, economical aspects, as well as a communication deficiency between professions in order to create a multimodal management of the condition, contribute to the poor outcome in symptomatic relief and overall treatment management? The inclusion of MT in existing treatment protocols, in particular OMT, is often non-existent. What effects could it have adding such interventions in protocol treatment?

For above stated reasons we aim to study the efficacy of multifaceted intervention programs involving one or several OMT techniques, as ways of contributing to the research groundwork for managing hip and knee OA irrespective of pharmacological treatment.

2.1 Leading question

This literature review sets out to investigate what results are found in today's protocols of multidisciplinary care of osteoarthritis of the hip or knee, where manual techniques applied in osteopathic practice are implemented. The project has been assigned with the following research question:

> *What potential role does manual techniques, as used in osteopathic practice have in multidisciplinary care of osteoarthritis of the hip or knee?*

3. Methodology

In this literature review, the databases PubMed, COCHRANE, CINAHL (Cumulative Index to Nursing and Allied Health Literature) and OVID were searched to gather material for the study. The following words and phrases were used to compose the final search string:

Title/abstract [tiab]	Osteoarthritis OR Degenerative arthritis OR Degenerative joint disease
	AND
Title/abstract [tiab]	Osteopathic medicine OR osteopathy OR osteopathic OR manipulation, osteopathic OR Medicine, Osteopathic OR Osteopathic Manipulative Medicine OR Manipulative Medicine, Osteopathic OR Osteopathic manual therapy OR Orthopedic manipulations OR Chiropractic OR musculoskeletal manipulations OR Manual therapy OR physiotherapy
	AND
Title/abstract [tiab]	Multimodal care OR multimodal rehabilitation OR multimodal OR multiple interventions OR Interdisciplinary OR Integrative OR Combined modalities OR multidisciplinary
	NOT
Title/abstract [tiab]	Arthroplasty OR Replacement OR Rheumatoid

Table 1. Words and phrases used during database search.

3.1 Literature research

Ultimately, seven articles met the set criteria as presented in figure 1.

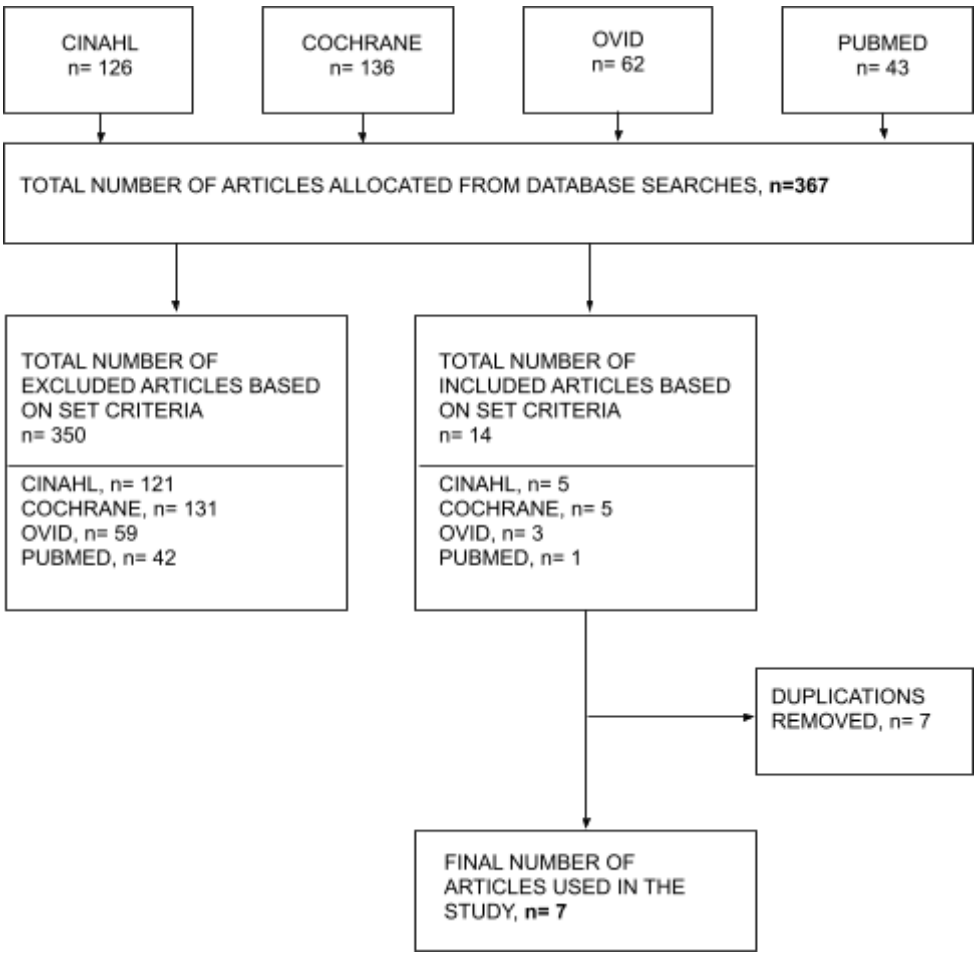

Figure 1. Literature research flow chart.

Each article was assessed via CASP (Critical Appraisal Skills Programme) as ways of determining trustworthiness, relevance and quality of results.

3.2 Inclusion and exclusion criteria

The following criteria were applied and adhered to when assessing the articles.

Inclusion Criteria	Exclusion Criteria
- Studies written in English - Studies where the population includes human adults - Studies including patients having symptomatic, radiographically confirmed OA of the hip or knee - Studies including treatment of OA with manual therapy and multimodal interventions - Original research articles - Studies measuring the clinical effects of the applied therapeutic intervention - Studies with treatment intervention being performed in person (physical practitioner-patient meeting) - Studies performed on patient group of more than 40 people - Access to the full article	- Included population should not suffer from inflammatory arthritis (including Rheumatoid arthritis) - Studies written before the year of 2000 - Studies on children and animals - Studies including osteoarthritis of other joints than the hip or knee - Patients undergone arthroplasty of affected joint - Patients recovering from other injuries of affected joint

Table 2. Inclusion and exclusion based set criteria.

The exclusion criteria are set out to eliminate potential data of bias. It is of great importance to critically and independently review scientific literature that can be potentially suboptimal, such as studies being executed within an unreasonable time frame in relation to data being collected, or studies based on prejudice and preconceptions about the final results.

3.2.1 Ethical consideration

When considering the ethical aspect of each article that was included in this review, it was discovered that four out of the reviewed studies had received regional ethics review board approval (Abbott et al., 2015; Poulsen et al., 2013; Abbott et al. 2012; Gwynn-Jones et al., 2018) while the remaining three studies received an institutional ethics review board approval (Bennell et al., 2004; Pollard et al., 2008; Sharma, 2013). All of the articles clearly stated that all participants provided written informed consent.

4. Results

The fallout of the search resulted in a total of seven studies written between the year 2004 to 2018. Out of those seven, three studies aimed to investigate interventions for OA of the knee alone, three involved both the osteoarthritic hip and knee, while one studied OA of the hip exclusively. Out of the seven articles that could be found using this method, six of them were randomized controlled trials, while one of them was a longitudinal study. Three of the studies were conducted in New Zealand, two in Australia, one in India and one in Denmark. In compilation of results for the various studies different outcome measurements were used, however the main focus remained the same, pain severity and physical function. A detailed chart of the articles is presented in table 3.

Article Number	Title	Author	Study Design	Country	Publication Forum	Publication Year	Intervention Groups	Diagnosis	Participants	Examiners
1	Efficacy of physiotherapy management of knee joint osteoarthritis: a randomised, double blind, placebo controlled trial	Bennell et al.	RCT	Australia	Annals of Rheumatic Diseases	2004	Physiotherapy; Placebo	Knee OA	119	10 physiotherapists
2	The incremental effects of manual therapy or booster sessions in addition to exercise therapy for knee osteoarthritis: a randomized clinical trial	Abbott et al.	RCT	New Zealand	Journal of Orthopaedic & Sports Physical Therapy	2015	Exercise therapy; Exercise therapy and Manual therapy; Exercise therapy and Booster sessions; Exercise therapy and Manual therapy and Booster sessions	Knee OA	66	Physical therapists
3	The effect of a manual therapy knee protocol on osteoarthritic knee pain: a randomised controlled trial	Pollard et al.	RCT	Australia	The Journal of the Canadian Chiropractic Association	2008	Macquarie Injury Management Group; Control group	Knee OA	43	N/A*
4	A Randomized Comparison of effectiveness of Clinical Exercises and Manual Therapy Procedures Versus Clinical Exercises alone in the Treatment of Osteoarthritis of Knee	Sharma	RCT	India	Indian Journal of Physiotherapy and Occupational Therapy	2013	Experimental Group; Control Group	Knee OA	40	N/A
5	Patient education with or without manual therapy compared to a control group in patients with osteoarthritis of the hip. A proof-of-principle three-arm parallel group randomized clinical trial	Poulsen et al.	RCT	Denmark	Osteoarthritis Research Society International (OARSI)	2013	Patient education program; Patient education program and Manual therapy; Minimal control intervention	Hip OA	111	1 physiotherapist; 1 chiropractor
6	Manual therapy, exercise therapy, or both, in addition to usual care, for osteoarthritis of the hip or knee: a randomized controlled trial. 1: clinical effectiveness	Abbott et al.	RCT	New Zealand	Osteoarthritis Research Society International (OARSI)	2012	Usual care; Manual physiotherapy; Multimodal exercise physiotherapy; Exercise therapy and Manual physiotherapy	Hip and Knee OA	193	General practitioners; 6 physiotherapists
7	Outcomes and factors influencing response to an individualized multidisciplinary chronic disease management program for hip and knee osteoarthritis	Gwynne-Jones et al.	Longitudinal study	New Zealand	The Journal of Arthroplasty	2018	Physiotherapist led out-patient clinic set within the orthopaedic department	Hip and Knee OA	218	Physiotherapists

* N/A = Not Applicable

Table 3. Overview of included studies.

4.1 Outcome measures

The most commonly used measurement system to determine the outcome in the various studies was the Western Ontario and McMaster Universities osteoarthritis index (WOMAC) which was used in four out of the seven studies that was chosen, where three articles used it as their primary measurement system (Abbott et al., 2012; Sharma, 2013; Abbott et al. 2015), while one used it as a secondary measurement system next to the VAS (Bennell et al., 2004). Another study to use the VAS as the primary measurement system was the article by Pollard et al., 2008, which was also the only trial not to use any secondary measurement system. In two of the studies that used the WOMAC for primary measures, The Outcome Measures in Rheumatoid Arthritis Clinical Trials - Osteoarthritis Research Society International (OMERACT-OARSI) criteria were used as a complementary measurement system.

In the RCT by Poulsen et al., the only article to investigate the hip alone, an 11-box NRS was used as the primary measurement system, to rate the worst pain that the participants were experiencing the previous week to check up on a scale form, while the Hip disability and Osteoarthritis Outcome Score (HOOS) made up the secondary measurement system with a range of 0-100, completed with a protocol to test ROM of the hip. Gwynne-Jones et al. used the Oxford Hip or Knee Score (OHKS) together with the SF-12, which takes into account the physical as well as mental aspects of the longer SF-36 protocol. The two forms are referred to as the Short Form Physical Component Summary (SF-12 PCS) and the Short Form Mental Component Summary (SF-12 MCS) scores.

Some studies also involved additional testing of the physical function as secondary measurement systems. Two of the RCTs included a 30-second sit-to-stand test, counting how many times the participants can do a sit-to-stand in 30 seconds from a chair, without using their arms. The same two studies also did a timed up and go test - examining the time it takes for a person to stand up from a chair, walk three meters, turn around and go back and sit down on the chair, without using the arms - as well as a 40-meter self-paced walk time test. Another article (Sharma, 2013) performed a six minute walk test. Two articles tested the Isometric quadriceps strength, where the knee was assessed at 60˚flexion in the sitting position using a KinCom dynamometer. In one

article alone (Abbott et al., 2012), a mental health test was performed as part of the investigation, screening for depression.

4.2 Intervention protocols

The selection of interventions varied throughout the exercise protocols presented in the reviewed articles. Several techniques were exclusively found in one article, such as the exercise protocol in article number one that combined concentric contraction of the quadratus lumborum with isometric contraction of gluteus maximus in sitting; isometric glute contraction in sitting with co-contraction of hip adductors; half squats performed with co-contraction of the glutes and hip adductors; and “Step Up” test onto a ten cm step with isometric contraction of glutes muscles onto the supporting leg while stepping up with the other leg, then lower back down to floor (Bennell et al., 2004). One article included ankle plantar flexor strengthening; hip abductor strengthening; hip lateral rotator strengthening; hip flexor and knee extensor stretching; and trunk muscle strengthening (Abbott et al., 2015), whilst another performed knee in mild-flexion to full extension or full-flexion; stationary bicycle; static quadriceps set; closed chain progression; seated leg presses; partial squat and step ups as intervention techniques (Sharma, 2013). Knee strengthening with three sets of ten repetitions of knee extension, hip extension, and knee flexion were found in one article (Abbott et al., 2012), whereas 60 seconds of passive stretch of the hip flexors, knee extensors, hip extensors, knee flexors, hip abductors and lateral rotators, and ankle plantar flexors were found in one article (Abbott et al., 2015).

In addition, several exercises were found in two of the articles. Aerobic exercises such as a ten minute walk or cycle, hip strengthening with three sets of ten repetitions of hip abduction, hip extension, hip lateral rotation, knee extension, 60 seconds of passive stretch of the knee flexors, knee extensors, ankle plantar flexors, neuromuscular coordination control exercises of the hip or knee where the patient were to execute three sets of two minutes of either standing weight-shifting exercises, standing balance on uneven surfaces, side-stepping, forward-backward and shuttle-walking drills, or stair walking were displayed in articles number two and six, both presented by the same head author (Abbott et al., 2012; Abbott et al., 2015). Both protocols from Abbott in 2012 and 2015 included additional booster sessions to the mandatory knee and/or hip

intervention protocols, where a minimum of six extra exercises or techniques were prescribed to adapt to each patient's condition.

There was great diversity in techniques presented in the included articles, alternating primarily between exercise therapy, MT and educational interventions. A summarized collection of the OMT techniques applied are presented in table 4.

OMT Techniques	**Article Number**
High-velocity amplitude-thrust (HVLA)	2; 4; 5
Articulatory techniques	1; 2; 4; 6
Recoil techniques	-
Soft tissue techniques	1; 2; 3; 4; 6
Muscle energy techniques (MET)	5
General osteopathic treatment	-
Functional technique	-
Strain-counterstrain	-
Facilitated positional release	-
BLT	-
Ligamentous articulatory strain	4
Myofascial release	-
Fascial unwinding	-
Myotensive techniques	-
Still technique	-
Exaggeration techniques	-
Cranial techniques	-
Visceral and neural mobilisation	-
Chapman's reflexes	-
Trigger points and neuromuscular techniques	2; 5
Lymphatic and visceral pump techniques	-

Table 4. Osteopathic Manipulative Treatment (OMT) Techniques (CEN, 2014) with corresponding article number where technique has been applied.

The articles displayed techniques used within the practice of osteopathy, some being OMT methods featured in varied articles and some solely found in one. One article included a multimodal program combining ankle and talocalcaneal joint distraction (thrust/non-thrust); ankle talocrural antero-posterior directed force (non-thrust); antero-posterior directed force to distal fibula, tibiofibular joint (non-thrust); lumbopelvic rotation (thrust); and soft tissue manipulation on the ankle plantar flexor muscle group (Abbott et al., 2015). Another article involved soft tissue massage of the knee performed in extension; thoracic spine mobilisation; and knee taping of the patella to adjust the components of medial glide, anterior tilt, lateral tilt and unload the infrapatellar fat pad or pes anserinus (Bennell et al., 2004). One article involved standing calf stretch; supine hamstring muscle stretch; prone quadriceps femoris muscle stretch; knee in mild-flexion to full extension or full-flexion; standing terminal knee extension; Maitland's technique; muscle stretching; soft tissue mobilization and ROM (Sharma, 2013). One presented myofascial manipulation and myofascial mobilisation technique (Pollard et al., 2008) whilst another article used trigger point release (TPPR), MET for muscular stretching and joint manipulation (with thrust) of the hip joint (Poulsen et al., 2013).

Solely two articles included the same OMT techniques, including antero-posterior directed force to the proximal femur (non-thrust); antero-posterior directed force to the tibia, tibio-femoral joint (non-thrust); knee extension (non-thrust); knee flexion (non-thrust); lateral hip distraction (non-thrust); long-axis hip distraction with thrust; manual stretch to quadriceps, hamstring, triceps surae muscle groups; manual stretches to connective tissue of hip and thigh; medial hip rotation (non-thrust); patellar gliding force (non-thrust); postero-anterior directed force to the proximal femur (non-thrust); postero-anterior directed force to the tibia, tibio-femoral joint (non-thrust); soft tissue manipulation to hip and thigh musculature and fascia; and soft tissue manipulation, quadriceps and peripatellar connective tissue, hamstring, hip adductor and triceps surae muscle groups (Abbott et al., 2012; Abbott et al., 2015).

Several of the articles have approached the care of OA with a multidisciplinary approach by combining interventions delivered with a wide range of health disciplines in their treatment protocols. One article included soft tissue massage, mobilisation, taping, isometric and concentric contractions, strength exercises and balance exercises (Bennell et al., 2004). Two articles included various mobilisation techniques with and

without thrust, several soft tissue techniques, aerobic exercises, stretching, strength exercises, and coordination control exercises (Abbott 2012; Abbott 2015). One included educational group sessions and personal interviews, trigger point release, MET, joint mobilisations and a self-stretch program (Poulsen et al, 2012). One included an individualized program where patients were referred to a dietitian, a physiotherapist, an occupational therapist and/or an orthotist (Gwynne-Jones, 2017). Sharma included stretching, various strength and ROM exercises, stationary bicycle, squats, step ups, Maitland's technique and soft tissue mobilisation (Sharma, 2013).

4.3 Clinical outcome

Out of the chosen articles, the RCT by Pollard et al. had the shortest time frame, consisting of a two week trial that compared one intervention group to one control group, where the intervention group were provided with a chiropractic knee protocol. Results showed that while there was no difference in outcome in the control group in comparison to baseline, the intervention group rated their pain less on the VAS scale, expressing that the knee pain to some extent lifted, in addition to also expressing a positive response to questions on whether they felt that the treatment had helped them or not.

In another article by Sharma there were similarly investigating two groups, one experimental group and one control group. The primary outcome that was presented using the WOMAC index investigated the progress after four weeks. The experimental group showed a better outcome at follow-up than did the placebo group in all subdivisions: pain, stiffness and physical function as well as total WOMAC score. Also, secondary measures in terms of ROM and a 6-minute walk test showed results in favor of the experimental group.

In an RCT by Paulsen et al., set in a hospital setting, that went on over the period of six weeks, three groups were examined, the first one being a patient education group, the other group receiving patient education together with MT, and the last one being a minimal control intervention group, which was only given home stretching. The article that set out to investigate hip OA, used the 11-box NRS to measure the primary outcome, where the focus was placed on pain severity. After 6 weeks there was no

distinction between the patient education group and the minimal control intervention group. A slight improvement was seen in the patient education and MT group, without seeing enough improvement to set it out as a statistically significant change. Secondary outcomes, counted using the hip disability and osteoarthritis outcome score (HOOS) did show results of clinical relevance and statistical significance for the MT and patient education group in comparison to the minimal control intervention and patient education group. Where results on pain reduction, performance in sport activities as well as the quality of life in relation to the hip, came out superior to those of improvements in terms of symptoms and function in daily situations, even if those subscales concordantly came out better for the MT and patient education group, just with less significant margins. On secondary outcomes measuring differences in ROM, no statistically significant changes were found.

The patient's own perceptions about the interventions were also reviewed. In this section the group with patient education and MT came out the strongest, with a percentage of 76.5 of patients believing that they had benefited from the interventions, compared to 22.2 % of the patient education, and 12.5 % of the minimal control intervention group (Paulsen et al., 2013).

The clinical trial by Benell et al 2004, had a slightly longer time frame where the first results were reported after Twelve weeks, and a follow up was performed 24 weeks from baseline. The study at hand included one physiotherapy group and one placebo group, where the intervention group consisted of taping, exercises, and massage. Primary measures were reported on the VAS scale, reporting pain on movement and patient global change in pain. The outcomes Twelve weeks after baseline showed improvements in both groups with a small marginal gain of the physiotherapy group, comparing the amount of 42 % improvers to that of 38 % of the placebo group. Whereas the global change in pain ended up being slightly higher in the placebo group, 72 % in difference to the 70 % of the intervention group. Reduction in pain that was considered to be of clinical significance were found in 53 % of the physiotherapy group and 47 % in the placebo group. At 24 weeks, movement pain, global improvement and reduction in pain as shown by measuring the results with the VAS scale showed continuous improvement from baseline, showing a marginally more advantageous outcome for the physiotherapy group compared to the assessment at Twelve weeks,

but still showing a very strong placebo outcome and minor differences in outcome between the two groups. Secondary measures did accordingly show resembling results between groups.

A trial by Abbott et al. 2012, stretched over a year and was primarily using the WOMAC index for measures. The study was performed on both the hip and knee and participants were allocated into four groups where patients received usual care, manual physiotherapy, multimodal exercise physiotherapy or combined exercise and manual physiotherapy. All the three intervention groups were assigned in addition to usual care. The results at follow up concluded a statistically significant improvement in all intervention groups, where the best results were seen in the manual therapy group indifferent to which joint that was affected out of the hip or knee. The exercise and combined MT and Exercise groups showed clinically relevant results, even if inferior to that of the manual therapy group. Secondary outcomes in the form of physical tests, timed up and go test, 30 s sit to stand test and 40 m self-paced walk test profited all intervention groups in comparison to the usual care group, even though the exercise intervention group had the best outcome out of the four.

Another RCT was published by Abbott et al. in 2015, investigating the knee alone. The article contained four groups: exercise therapy, exercise therapy with booster sessions, exercise therapy and MT, and exercise therapy and MT with booster sessions, where the primary outcomes were measured using WOMAC in the version NRS 3.1. The exercise therapy consisted of four mandatory knee exercises, and six additional booster sessions prescribed to individually adapt to the patient needs. The MT consisted of seven mandatory treatments, and an additional six booster sessions individually adapted. The six booster treatments in each group respectively, were chosen from a list of twelve exercise techniques, and 19 MT techniques, both reflecting the mandatory or secondary exercises and MT techniques presented above (Abbott et al., 2015). The study did respectively acquire a one year follow up. The outcome showed best support for the exercise group with booster sessions together with the group where exercise was combined with MT. The group consisting of exercise- and MT together with booster sessions showed no more success than did the group consisting of exercise alone.

Out of the research articles, the last one was a longitudinal study that went on for the longest period of time out of the articles chosen. With the largest number of participants, the study by Gwynne-Jones et al. published in 2018 stretched over a time frame of two years presenting the results of 218 participants that passed through a joint clinic that was setup at the orthopedic unit at the Dunedin public hospital. Out of the patients that participated in the study 44 % had hip OA, and 56 % knee OA. All participants were examined at baseline using the Oxford Hip and Knee Score (OHKS) whereas 194 patients also did a full SF-12 score. The outcome for participants with hip OA was negative on all scales, while participants with Knee OA showed a positive change on the OHKS score and SF-12 PCS, although a less good outcome on the SF-12 MCS. The outcome suggests that 57 out of 218 (26 %) responded with an improved Oxford score to compare with 27 % of patients responding accordingly with the SF-12 PCS and 25 % on the MCS. In contrast the same numbers for worsening in patients was seen in 70 participants (32 %) on OHKS, 27 % on SF-12 PCS and 40 % on SF-12 MCS. The comparison of results for the Knee on OHKS was a 35 % improvement compared to 21 % of participants that worsened. The numbers of the hips show a 15 % improvement on OHKS compared to a 45 % decline in OHKS index of the hip. The results show better outcomes for the Knee OA compared to hip OA. Association between the nature of the score and gender could not be made. Correlations between age and a decline in OHKS could be seen in spite of the joint involved. With the SF-12PCS measure, an interrelationship with age was seen only when examining the hip joint, while the mental aspect of the SF-12 MCS did not seem to be associated with age at all.

5. Discussion

To be able to answer the question of what potential role manual techniques used in osteopathic practice could have in multidisciplinary care of osteoarthritis of the hip or knee, attentiveness must be paid to the interrelations between the outcome of the research articles, which manual therapy techniques were used, how many interventions were incorporated and which combinations turned out to be beneficial for the hip and knee respectively.

Bennell et al. used the least amount of MT treatment in their management protocol, where thoracic mobilisation and knee soft tissue massage were the only techniques used beside the control group that involved a sham ultrasound and cutaneous application of a non-potent gel. The control group and intervention group were both presenting with similar results, with just a few percent difference (Bennell et al., 2004). However, there was little resemblance of the two groups, which is interesting considering no other trial had as high of an outcome in the control group as in this study. One could argue that this evident disparity of procedures can affect the outcome of results when comparing placebo and non-placebo effects. On the other hand, what kind of sham technique could be similar to the involved MT techniques, and still leap no risk of producing any other effects than those of placebo? In the control group of Pollard et al., the sham procedure involved manual contact to the knee without force application, followed by interferential therapy (IFT) with application of low frequency electrical currents set at zero (Pollard et al, 2008). This type of manually resembling sham procedure, where physical contact is combined with non-effective electrical input, could potentially have contributed with different outcomes than non-physical interventions such as ultrasound or gel application.

Alongside the placebo treatment in the article by Bennell et al., it could be questioned why the MT treatment was so sparse, and how the results would have turned up would the intervention protocol have been involving more than one technique for the knee and surrounding structures. Furthermore, 67 % of the participants remained blinded to their group allocation, however it is not specified if the enduring 33 % were allocated to the placebo group or intervention group (Bennell et al., 2004). This would have been valuable information to take into account when measuring effectiveness of results from each group respectively. In comparison, the demonstration of the treatment protocol in the article by Abbott et al., 2015 was highly thorough, making the results clear to measure and comprehend. The structure of the protocol allowed for individualization of techniques performed, encouraging a person-centered attitude and tailored to fit the patient's specific needs. However, the authors failed to present the specific details regarding what type of booster sessions and potential additional exercises each patient received. Thus, in addition to the mandatory interventions of each group, it remains unclear what additional six booster sessions were chosen out of the 19 MT techniques and twelve exercises.

In addition, there was a notable improvement in the exercise group with booster sessions, and the exercise and MT group, whilst the exercise and MT group with booster sessions did not show up with better results than the exercise therapy alone (Abbott et al., 2015). It is questionable why the additional booster sessions did not affect the outcome of the exercise and MT group, considering the added effect of booster sessions when combined with exercise therapy alone and the effect of the exercise together with MT. One factor could be that the exercise and MT group did in fact have more therapist interaction than the exercise and MT group with booster sessions did, with a mean value of 622 compared to 740 minutes per patient. Otherwise there is not much to suggest why the effect of treatment with booster sessions and MT in combination would cause a deteriorating result in comparison to the interventions applied separately. Perhaps further research must be made and with larger groups of participants.

In contrast to the study by Abbott et al., that went on for a year, Pollard et al. conducted the most short-lived study out of the articles, to investigate more short-term effects, covering a timeframe of two weeks. The article only included two different MT techniques, myofascial treatment in the area around the knee, as well as a thrust manipulation to the knee. In treatment protocol, no other field of practice included, thus decreasing the number of comparable results when measuring effects of OMT techniques in relation to other fields of multidisciplinary OA management. The results from this protocol demonstrated that there was no difference in the placebo group before baseline and at follow-up, whilst the MT techniques presented with bettered results with patients expressing a positive outcome of treatment and decreased pain score (Pollard et al., 2008). This implies an overall positive, affirmative outcome of MT techniques being effective in management of knee OA.

The study by Pollard et al. solely included VAS as their primary outcome measure, with no secondary outcome nor physical examination, which could be questioned when examining the quality and reliability of data. Furthermore, the randomisation procedure is debatable in that allocation was unequal by design. All patients picked one out of two cards from a box, receiving their group allocation number, before replacing the card into the same box for the next patient to potentially pick (Pollard et al., 2008). This generated one intervention group of 26 participants, and one control group of 17 participants. One could wonder why the participants were not allocated into groups of

22 and 21, and how this potentially might have affected the outcome. On the other hand, a benefit of the study protocols by Pollard et al. was that they included pictures of each technique being performed, thus enhancing future ability to replicate the interventions performed. The same was true for the study by Sharma, which also provided pictures of all positions in relation to the techniques presented.

The four-week long study by Sharma in 2013 comprised treatment with MT and exercise protocols. The techniques in the protocol that could fall under the category of osteopathic techniques, as defined by CEN, were: articulatory techniques, HVLA, soft tissue techniques and ligamentous articulatory strain techniques. The joints treated were the tibiofemoral and patellofemoral joints. While the protocol did not give space to consider surrounding joints in an osteopathic whole-person manner (CEN, 2014), it did consist of many different types of articulations for each joint. Results demonstrated that the experimental intervention group showed increased positive outcome in comparison to the placebo group on all counts and in total WOMAC-score (Sharma, 2013). Both groups improved significantly with physical examinations such as ROM and six min walk test presenting with enhanced results, nevertheless, the MT and clinical exercise group combined were more successful than the clinical exercise group alone in reducing pain and increasing ROM of the knee.

Poulsen et al. concluded a six week trial consisting of a minimal control intervention group and a PE program with or without MT, where the MT enclosed three different MT techniques, all of which can also be found amongst the techniques listed as osteopathic; trigger point release, MET and HVLA. The techniques were applied in that particular order, and while the program were allowed to be individualized according to where trigger points were found - it was only allowed for treatment to be performed locally around the hip joint and musculature. The result showed a modest difference in PE and MT combined in primary outcome via NRS-11 box, whereas the other interventions showed no change in results. Secondary outcomes via HOOS showed clinical relevance and statistical significance for PE and MT in means of pain reduction, better performance in sports and QOL. In means of change in symptoms, ROM and function in daily situations the outcomes were less improved (Poulsen et al., 2013). The results of function in daily situations in relation to QOL could be considered contradictory due to their natural impact in the overall experience of a person's life.

In the article by Abbott et al., 2012, the MT group also demonstrated with the best results. In this article the MT was applied in addition to usual care instead of PE and independent of which joint was affected out of the hip or knee. Despite this, the results presented with statistically better improvements in all intervention groups. The exercise and MT group, and the exercise group alone - in addition to usual care - showed clinically relevant results, despite being inferior to the MT group, but superior to the group that only received usual care (Abbott et al., 2012). An important factor to bear in mind was the amount of time. In this trial, the sum of treatment therapist interaction was aimed at being assigned equally between intervention groups, meaning that in the exercise and MT group, the time had to be split on the different therapies in comparison to the exercise or MT group where all time was spent on the same type of therapy, meaning that the combined intervention group might have had fewer good outcomes due to that too little time was spent on each section.

Considering that the MT group had a particularly strong outcome in the article by Abbott in 2012, it is interesting to note that it also had one of the more extensive MT protocols. The MT consisted of seven mandatory treatments, and an additional six boosters, individually adapted to the patient's needs. The six additional boosters were chosen from a list of nine MT techniques for the hip and twelve for the knee, to create a treatment more adapted to the patient, encouraging a person-centered attitude, tailored to fit the patient's specific needs. Additionally both groups were given a home programme where they were prescribed up to six ROM exercises to boost the effect of the treatment further (Abbott et al., 2012).

When examining what manual techniques were performed in this study, results indicated that both thrust and non-thrust mobilisations, soft tissue treatment, general articulations and manual connective tissue stretches were used (Abbott et al., 2012). Interestingly, in regard to OMT, all techniques used in the protocol are typical in an osteopathic setting (CEN, 2014). Accordingly, the protocol provided alternatives for both the hip and knee to work with surrounding areas. For instance, the boosters of the hip protocol included techniques for the pelvis, lumbar spine, knee, patella, distal and proximal tibio-fibular joints, talo-crural and talo-calcaneal joints. The boosters for the knee protocol included techniques for the pelvis, lumbar spine, several hip techniques, talo-crural and talo-calcaneal joints as well as distal and proximal tibio-fibular joints (Abbott et al., 2012). This supports evidence that encourages OMT in future

management of OA, since an important part of osteopathic practise is the whole-person perspective where the body works as a unit, and the various parts of the body are closely integrated in a complex manner, meaning no part should be treated in isolation (CEN, 2014).

In terms of the results from Abbott et al. 2012, quite many of the patients received replacement surgery after baseline visit during the study, indicating that they were unable to carry out the full extent of the treatment plan. This evidently affects the results at the follow up visit as participants who received arthroplasty were taken out of the measure during mid-study. This might have changed the outcome to appear better or worse than it otherwise would have been, despite the results having been counted with and without patients that had undergone replacement surgery and might not be due to the interventions of the study itself. Patients that had undergone arthroplasty was included in the exclusion criteria of this review, however it was much later in the process of conducting the results of all seven articles that it became evident that the study by Abbott et al. had participants that had undergone arthroplasty during the timeframe when the study was conducted, this despite the article itself having arthroplasty as an exclusion criteria for attendance at baseline visit. The arthroplastic procedures were not forecasted by the authors, and thus continuously enclosed in this review.

The final study by Gwynne-Jones et al. conducted a study with the largest group of participants, the only longitudinal study and the study that comprised over the longest period of time following patients that were assigned to a program set at a joint clinic. An interesting aspect from the article was the usage of different scales, since outcomes did differ a bit using the various measurement systems. While all patients did an OHKS at baseline and follow up, only 89 % of patients completed the SF-12. However, even though the numbers differed somewhat, both outcomes were in favor of younger patients and those that had knee OA in comparison to those that had hip OA. No differences were seen when taking gender into account (Gwynne-Jones et al., 2018).

In the program it was specified that participants could be referred to various professionals within different occupations, such as dietists, orthotists, physiotherapists, and/or occupational therapists, as ways of assuring an individualized and multimodal treatment plan. It was however not presented in the article what was done for each

individual patient, how many interventions that were performed per patient, or how many professions were involved on average. Neither was it included how or if the treatment protocols for hip and knee OA differed, which would be of interest considering that the outcome for patients with knee OA was superior to that of patients with hip OA.

Another difficulty with the protocol by Gwynne-Jones et al. was to understand the impact of the MT, if it was used for all patients, and if techniques that could be found in an osteopathic setting were in fact included in the study. Since it can not be determined what types of treatments were used, it is also difficult to analyse what parts of the protocol that potentially could have been improved, and if hip OA in general is more difficult to manage in this age-group or if the program itself was just not as well fitted to the hip as it was to the knee.

Out of the seven studies, two were led by the same author, Professor J. Haxby Abbott (2012, 2015), whereas the remaining research groups had published one study each on the subject at hand, at the time for inclusion. Again, this indicates that in-depth research in this field is scarce. Another important consideration to include as to whether it could potentially steer the quality of data in a favourable or suboptimal direction is that the article by Sharma was single-handedly written by the one author presented. If there were several authors operating the study, more authoritative administrators would examine the work conducted and risk of potential inclination might be reduced.

As presented in table 4, out of the 19 OMT techniques defined by CEN, most articles included articulatory techniques and soft tissue techniques when treating OA. Two articles also included HVLA, two included trigger points and neuromuscular techniques and one included MET. The remaining 14 OMT techniques seem to have been omitted in treatment protocol, presumably due to some of them potentially not being optimal in the initial management of OA, whereas many of them could potentially serve as good complementary techniques in ways to treat and alleviate dysfunctional manifestations from adverse effects of OA. For instance, lymphatic techniques could decrease subsequent swelling around the joint; BLT to normalize joint function; or strain-counterstrain to promote better proprioception and neurological changes in

involved muscles, fascia and joint structures (Chaitow, 2018), thus increasing the QOL of patients suffering from OA.

Even though the field of rehabilitation often has a weak seat of evidence to lean on, this does not imply that treatments available are not good, but that in many cases it is difficult to evaluate physiotherapeutic and occupational therapy interventions in a systematic way. When it comes to treatment of OA, however, there is strong evidence presented where researchers all over the world agree that mild to moderate OA is best treated with information, education, training and, if necessary, lifestyle changes and possible weight reduction (BOA-register, 2019). There is also a consensus that the diagnosis of OA of the hip and knee should be made with the help of a history and clinical examination (BOA-register, 2019).

An important issue demonstrated in the BOA-register's annual report 2019, is that X-ray changes are rarely seen in the early stages of OA, and there is little reason to perform X-ray examinations in the initial state of OA process since an X-ray examination without findings can lead to delayed diagnosis and treatment, which in turn is clearly disadvantageous for the patient. Once OA has become established, it is unfortunately uncommon to see radiographic reversed degeneration in joint structure. However, this must not equate to a negative progress in terms of pain and physical impairments (London: Royal College of Physicians; 2008).

Another great concern is that 2019's annual cost in Sweden for X-ray examination of the hip and knee added up to SEK 7.5 million due to 68 % of the 16,644 newly registered patients in the BOA register having undergone X-ray (BOA-register, 2019). Thus, according to current national guidelines from the National Board of Health and Welfare and the BOA register's goal, a maximum of 50 % of patients being x-rayed before initiating OA treatment would decrease the financial load from X-ray examination with two million SEK in one year and even more greatly in the years ahead (BOA-register, 2019).

Millions of SEK are spent annually in Sweden on OA X-ray examination and the MSD and OA will continue to increase as the overall life expectancy is continuously increasing. This also indicates that as this pattern persists, society will face higher

costs and future health-care services will be burdened even more than they are currently as the financial pressure is expected to rise even further in the coming decades (Ahlberg, 2012). The evident need of more effective ways of carrying out early stage diagnosis suggests that a future crucial aim should be to prevent and treat the disease's progression by recruiting the best possible clinicians suitable to initiate best available diagnosis and treatment, whilst decreasing the financial burden on society and the field of health care by promoting research of cost-effective and preventive treatment modalities. This is where OMT could potentially have a strong impact as many techniques used in OA management protocol are typical in an osteopathic setting, where the osteopath place emphasis on diagnosing, treating and alleviating dysfunctional manifestations such as OA (Description of Osteopathy | EFFO, 2021), and possibly contribute by decreasing the subsequent delay on early diagnosis and management of OA, thus decreasing the financial burden from radiographics and the subsequent load on primary care.

Finally, when viewing the methodology and possible improvement potential there are components that could have been more optimally executed. First, more than four databases could have been searched to collect more articles for this review. For that, however, full access to databases would have been required. Furthermore, a personal greater experience in conducting research papers and assessing their credibility would have potentially contributed with a more substantiated literature review. In addition, when beginning to compose search strings in the initial phase of the methodology, very few MESH terms were initially used in combination of not properly understanding how to technically formulate the searches into the databases selected. This led to the initial few searches resulting with either several thousand or barely a dozen of articles. The process improved immensely when introducing the usage of title abstract [tiab] and writing one separate line for the condition, one for the treatment and one for what to be excluded.

Lastly, considering how the project could be refined for the future, the intervention protocols from each article were presented as means of what and how many MT techniques, OMT techniques, and multidisciplinary protocols were found. In retrospect, it would have made more sense to present each article in a sequential order instead of intermingling techniques from all seven articles as it might have presented with a more

understandable section of intervention data. On the other hand, an additional presentation in form of a table or figure of what OMT and MT techniques, and multimodal interventions would be needed to add.

5.1 Limitations

The study had a number of limitations. Full access to some research articles was declined, affecting the result of articles available for screening. Furthermore, as of today there is insufficient research published on OMT and OA, MSD and OMT, and multimodal management of OA. For this reason, our results on above stated insufficiencies might have been different if we were to include other joints than the knee and hip. In addition, the studies assessed were carried out in a few countries, thus confining a broader understanding of the worldwide burden of OA. Three articles were conducted in New Zealand, two in Australia, and one respectively in India and Denmark. It would have been valuable to compare more studies from across the globe as ways of measuring statistics of OA in general, OA of the hip and knee, what treatment protocols are most effective, and how the overall management of OA is executed. Lastly, the authors of this review do not hold adequate clinical experience of the condition examined.

6. Conclusion

The included studies suggest that OMT can have a beneficial effect in the management of hip and knee OA. However, the presence of osteopathic interventions is as of today very limited in research available. Further research is therefore needed to determine the effects of OMT in multimodal clinical practice for patients with OA.

References

Ahlberg, I., 2012. The economic costs of musculoskeletal disorders. A cost-of-illness study in Sweden for 2012. Lund: Lund University School of Economics and Management, pp.1; 23-24.

Altinbilek, T., Murat, S., Yumuşakhuylu, Y., İçağasioğlu, A. 2018. Osteopathic manipulative treatment improves function and relieves pain in knee osteoarthritis: A single-blind, randomized-controlled trial. Turkish Journal of Physical Medicine and Rehabilitation, 64(2), pp.114-120.

Abbott, J., Chapple, C., Fitzgerald, G., Fritz, J., Childs, J., Harcombe, H. and Stout, K., 2015. The Incremental Effects of Manual Therapy or Booster Sessions in Addition to Exercise Therapy for Knee Osteoarthritis: A Randomized Clinical Trial. *Journal of Orthopaedic & Sports Physical Therapy*, 45(12), pp.975-983.

Abbott, J., Robertson, M., Chapple, C., Pinto, D., Wright, A., Leon de la Barra, S., Baxter, G., Theis, J. and Campbell, A., 2012. Manual therapy, exercise therapy, or both, in addition to usual care, for osteoarthritis of the hip or knee: a randomized controlled trial. 1: clinical effectiveness. *Osteoarthritis and Cartilage*, 21(4), pp.525-534.

Barten, D., Swinkels, I., Dorsman, S., Dekker, J., Veenhof, C. and de Bakker, D., 2015. Treatment of hip/knee osteoarthritis in Dutch general practice and physical therapy practice: an observational study. *BMC Family Practice*, 16.

Bennell, K.L., Egerton, T., Pua, Y-h., Haxby Abbott, J., Sims, K., Metcalf, B., Mcmanus, F., Wrigley, T.V., Forbes, A., Harris, A., Buchbinder, R. 2010. Efficacy of a multimodal physiotherapy treatment program for hip osteoarthritis: A randomised placebo-controlled trial protocol. *BMC Musculoskeletal Disorders*, vol. 11, no. Art. No. 238, 1-13. (doi: 10.1186/1471-2474-11-238).

Bennell, K., Hinman, R., Metcalf, B., McConnell, J., McColl, G., Green, S. and Crossley, K., 2004. Efficacy of physiotherapy management of knee joint osteoarthritis: a

randomised, double blind, placebo controlled trial. Annals of the Rheumatic Diseases, 64(6), pp.906-912.

Bjerså, K., 2012. Complementary and Alternative therapies in Surgical Care. *University of Gothenburg, Sahlgrenska Academy*, p.29.

Cameron, M. 2002. Is manual therapy a rational approach to improving health-related quality of life in people with arthritis? *Australas Chiropractic & Osteopathy: journal of the Chiropractic & Osteopathic College of Australasia*, 10(1):9-15.

Castaño Betancourt, M.C. 2015. Hip Osteoarthritis: Genetics, epidemiological risk factors and burden of the disease. *Erasmus University Rotterdam*.

Chaitow, L., 2018. *Fascial dysfunction*. 2nd ed. Handspring Publishing Limited.

Comité Européen de Normalisation (CEN), 2014. *Standard EN16686 for osteopathic practice and education*. Austria: CEN's Project Committee on 'Services for Osteopaths' (CEN/TC 414), p.24.

Critical Appraisal Skills Programme (2018). CASP (Randomised Controlled Trials) Checklist. [online] Available at: <https://casp-uk.net/casp-tools-checklists> [Accessed: 8 January 2021].

Dieppe, P.A., Lohmander, L.S. 2005. Pathogenesis and management of pain in osteoarthritis. *Lancet*, 365(9463):965–973.

European Federation & Forum for Osteopathy. 2021. *Description of Osteopathy | EFFO*. [online] Available at: <https://www.effo.eu/description-of-osteopathy/> [Accessed 15 March 2021].

Felson, D.T. 2009. Developments in the clinical understanding of osteoarthritis. *Arthritis Research & Therapy,* 11:203 (doi:10.1186/ar2531).

French, H., Brennan, A., White, B. and Cusack, T., 2011. Manual therapy for osteoarthritis of the hip or knee – A systematic review. *Manual Therapy*, 16(2), pp.109-117.

Glyn-jones, S., Palmer, A. J., Agricola, R., Price, A. J., Vincent, T.L., Weinans, H. & Carr, A. J. 2015. Osteoarthritis. *Lancet*, 386, 376-87.

Gwynne-Jones, D., Gray, A., Hutton, L., Stout, K. and Abbott, J., 2018. Outcomes and Factors Influencing Response to an Individualized Multidisciplinary Chronic Disease Management Program for Hip and Knee Osteoarthritis. *The Journal of Arthroplasty*, 33(9), pp.2780-2786.

Hansson, E.E., Jonsson-lungren, M., Ronnheden, A.M., Sorensson, E., Bjarnung, A., Et Al. 2010. Effect of an education programme for patients with osteoarthritis in primary care – a randomised controlled trial. *BMC Musculoskelet Disord*. 11:1471–2474.

Heidari, B. 2011. Knee osteoarthritis prevalence, risk factors, pathogenesis and features: Part I. *Caspian J Intern Med. Spring*; 2(2): 205–212.

Hopman-rock, R.M., Westhoff, M.H. 2000. The effects of a health educational and exercise program for older adults with osteoarthritis for the hip or knee. *J Rheumatol*. 8:1947–54.

Hunter, D.J. 2011. Lower extremity osteoarthritis management needs a paradigm shift. *British Journal of Sports Medicine,* 45:283-8 (doi: 10.1136/bjsm.2010.081117).

Hunter, D., March, L. and Chew, M., 2020. Osteoarthritis in 2020 and beyond: a Lancet Commission. *The Lancet*, 396(10264), pp.1711-1712.

The International Federation of Orthopaedic Manipulative Physical Therapists (IFOMPT), 2016. *Educational Standards In Orthopaedic Manipulative Therapy*. Part A: Educational Standards 2016. p.31.

Jordan, K.M., Sawyer, S., Coakley, P., Smith, H.E., Cooper, C., Arden, N.K. 2004. The use of conventional and complementary treatments for knee osteoarthritis in the community. *Rheumatology,* 43:381–384 (doi:10.1093/rheumatology/keh045).

Jordan, K.M., Arden, N.K., Doherty, M., Bannwarth, B., Bijlsma, J.W., Dieppe, P., Gunther, K., Hauselmann, H., Herrero-beaumont, G., Kaklamanis, P., Lohmander, S., Leeb, B., Lequesne, M., Mazieres, B., Martin-mola, E., Pavelka, K., Pendleton, A., Punzi, L., Serni, U., Swoboda, B., Verbruggen, G., Zimmerman-gorska, I., Dougados, M; Standing Committee for International Clinical Studies Including Therapeutic Trials ESCISIT. 2003. EULAR Recommendations 2003: an evidence based approach to the management of knee osteoarthritis: Report of a Task Force of the Standing Committee for International Clinical Studies Including Therapeutic Trials (ESCISIT). *Ann Rheum Dis.* 62(12):1145-55 (doi: 10.1136/ard.2003.011742).

Kuchera M. L., 2007. Applying osteopathic principles to formulate treatment for patients with chronic pain. *The Journal of the American Osteopathic Association*, *Vol.107*(10 Suppl 6), ES28–ES38.

Lalit, S.Y., Suhas, M.B., Amita, M. 2012. Effect of Manual Therapy Techniques on Knee Proprioception in Patients with Osteo-arthritis of Knee. Indian Journal of Physiotherapy & Occupational Therapy July-Sept., 2012, Vol. 6, No. 3.

Marra, C., Cibere, J., Grubisic, M., Grindrod, K., Gastonguay, L., Thomas, J., Embley, P., Colley, L., Tsuyuki, R., Khan, K. and Esdaile, J., 2012. Pharmacist-initiated intervention trial in osteoarthritis: A multidisciplinary intervention for knee osteoarthritis. *Arthritis Care & Research*, 64(12), pp.1837-1845.

Miller, L.E., Block, J.E. 2013. An 8-week multimodal treatment program improves symptoms of knee osteoarthritis: a real-world multicenter experience. *Pragmatic and Observational Research*, 4:39-44 (doi: 10.2147/POR.S53608).

National Collaborating Centre For Chronic Conditions (Uk), 2008. Osteoarthritis: National Clinical Guideline for Care and Management in Adults. London: Royal College of Physicians (UK)

Palazzo, C., Nguyen, C., Lefevre-Colau, M., Rannou, F. and Poiraudeau, S., 2016. Risk factors and burden of osteoarthritis. *Annals of Physical and Rehabilitation Medicine*, 59(3), pp.134-138.

Peterson K, Anderson J, Bourne D, Mackey K, Helfand M. Effectiveness of models used to deliver multimodal care for chronic musculoskeletal pain: A rapid evidence review. J Gen Intern Med. 2018 Vol.33(Supplement 1), pp.71-81.

Pollard, H., Ward, G., Hoskins, W., Hardy, K. 2008. The effect of a manual therapy knee protocol on osteoarthritic knee pain: a randomised controlled trial. J Can Chiropr Assoc. 2008 Dec; 52(4): 229–242.

Poulsen, E., Hartvigsen, J., Christensen, H., Roos, E., Vach, W. and Overgaard, S., 2013. Patient education with or without manual therapy compared to a control group in patients with osteoarthritis of the hip – a proof of principle three-arm parallel group randomized clinical trial. *Osteoarthritis and Cartilage*, 21, p.S145.

Roos, E. M. & Juhl, C. B. 2012. Osteoarthritis 2012 year in review: rehabilitation and outcomes. *Osteoarthritis Cartilage*, 20, 1477-83.

Rosemann, T., Joos, S., Laux, G., Gensichen, J., Szecsenyi, J. 2007. Case management of arthritis patients in primary care: a cluster-randomized controlled trial. *Arthritis Rheum*. 57(8):1390–7.

Salmon, J., Rat, A., Sellam, J., Michel, M., Eschard, J., Guillemin, F., Jolly, D. and Fautrel, B., 2016. Economic impact of lower-limb osteoarthritis worldwide: a systematic review of cost-of-illness studies. *Osteoarthritis and Cartilage*, 24(9), pp.1500-1508.

Safiri, S., Kolahi, A., Hoy, D., Buchbinder, R., Mansournia, M., Bettampadi, D., Ashrafi-Asgarabad, A., Almasi-Hashiani, A., Smith, E., Sepidarkish, M., Cross, M., Qorbani, M., Moradi-Lakeh, M., Woolf, A., March, L., Collins, G. and Ferreira, M., 2020. Global, regional, and national burden of neck pain in the general population,

1990-2017: systematic analysis of the Global Burden of Disease Study 2017. *BMJ*, 79, pp.819-828.

Sharma, S., 2013. A Randomized Comparison of effectiveness of Clinical Exercises and Manual Therapy Procedures Versus Clinical Exercises alone in the Treatment of Osteoarthritis of Knee. *Indian Journal of Physiotherapy and Occupational Therapy - An International Journal*, 7(3), p.198.

Swedish Standards Institute (SIS), 2015. *Hälso- och sjukvårdstjänster av osteopater - Osteopathic healthcare provision* (SS-EN 16686:2015). Svenska institutet för standarder. <https://www.sis.se/api/document/preview/8014857/> [Accessed 14 March 2021].

Sutton, D.A., Côté, P., Wong. J.J., Varatharajan, S., Randhawa, K.A., Yu, H., Southerst, D., Shearer, H.M., Van Der Velde, G.M., Nordin, M.C., Carroll, L.J., Mior, S.A., Taylor-vaisey, A.L., Stupar, M. 2014. Is Multimodal care effective for the management of patients with whiplash-associated disorders or neck pain and associated disorders? A systematic review by the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration. *The Spine Journal*, 16(12):1541-1565. (doi: 10.1016/j.spinee.2014.06.019).

The BOA-register, 2013. *The BOA-register, "Better Management of patients with Osteoarthritis"*. [online] pp. 50-51. Available at: <https://registercentrum.blob.core.windows.net/boa/r/Better-Managment-of-OsteoArthritis-BOA-Annual-Report-2013-rkM1Ilwbe.pdf> [Accessed 11 February 2021].

The BOA-register, 2019. *The BOA-register, "Annual Report"*. [online] pp. 22. Available at: <https://registercentrum.blob.core.windows.net/boa/r/BOA-arsrapport-2019-rkgjznTaNw.pdf> [Accessed 15 February 2021].

Turkiewicz, A 2016, *'Epidemiology of osteoarthritis in Sweden. Register and cohort studies on prevalence and mortality.',* Doctor, Department of Clinical Sciences, Lund, Lund.

Van Baar, M.E., Dekker, J., Oostendorp, R.A., Biil, D., Voorn, T.B., Lemmens, J.A., Et Al. 2001. The effectiveness of exercise therapy in patients with osteoarthritis of the hip or knee: a randomized clinical trial. *J Rheumatol*. 25(12):2432–9.

Vögele, T. J., Prodinger, A. P. 2019. Osteopathic Treatment of Patients with Coxarthrosis: A Randomised Controlled Trial. *European Journal of Osteopathic Research,* 1:1, 8-16 (doi: https://doi.org/10.35740/EJOR.2019.1.1.2).

Woolf, A. D. & Pfleger, B. 2003. Burden of major musculoskeletal conditions. *Bull World Health Organ*, 81, 646-56

World Health Organization. 2021. *Musculoskeletal conditions*. [online] Available at: <https://www.who.int/news-room/fact-sheets/detail/musculoskeletal-conditions> [Accessed 8 February 2021].

Zhang W, Moskowitz Rw, Nuki G, Et Al. 2008. OARSI recommendations for the management of hip and knee osteoarthritis, Part II: OARSI evidence-based, expert consensus guidelines. *Osteoarthritis Cartilage,* 2008;16:137–62.

Zhang, Y. and Jordan, J., 2010. Epidemiology of Osteoarthritis. *Clinics in Geriatric Medicine*, 26(3), pp.355-369.

List of abbreviations

BLT	Balanced ligamentous tension
CEN	European committee for standardization
HOOS	Hip disability and Osteoarthritis Outcome Score
IFT	Interferential therapy
MET	Muscle energy technique
MMT	Multimodal treatment
MSD	Musculoskeletal disorder
MT	Manual therapy
NSAIDs	Non steroidal anti inflammatory drugs
OA	Osteoarthritis
OHKS	Oxford Hip or Knee Score
OMERACT-OARSI	Outcome Measures in Rheumatoid Arthritis Clinical
OMT	Osteopathic manipulative treatment
PE	Patient education
QOL	Quality of life
ROM	Range of motion
SF-12 PCS	Short Form Physical Component Summary
SF-12 MCS	Short Form Mental Component Summary scores
VAS	Visual analogue scale
WOMAC	Western Ontario and McMaster Universities osteoarthritis index
	Trials-Osteoarthritis Research Society International