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The Role of High-Intensity Training in Osteopathic Management of Chronic Low Back Pain

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Abstract

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Chronic low back pain is one of the most common non-communicable diseases worldwide and one of the leading causes of disability. It is classified as pain lasting longer than 12 weeks. 85% of all back pain is caused by non-specific reasons. Patients with CLBP have a wide range of associated symptoms and problems, involving physical, psychological, and physiological areas of their lives. Low back pain is one of the highest patient representations in osteopathic clinics and regularly treated by osteopaths.

This thesis reviewed the role of high-intensity training as a treatment modality for chronic low back pain and the difference between the intervention effects between low-intensity training and high-intensity training.

Results showed that high-intensity exercise was an effective intervention in significantly increasing the strength in patients with CLBP and equally as effective as low-interval training in increasing disability, quality of life and exercise capacity. Physical activity and exercise is seen as a vital sign of health in the field of osteopathy and something that is regarded as important to be considered in patient centred care. Exercise ordination is commonly seen being incorporated into the management of various conditions, especially in treatment of low back pain by osteopaths.

Keywords: Chronic low back pain; CLBP; Chronic non-specific low back pain; CNSLBP; High-intensity training; HIT; High-intensity interval training; HIIT; Osteopathy

Contents

1 Abbreviation

Table 1. List of abbreviations.

Abbreviation	Meaning
CLBP	Chronic Low Back Pain
CNSLBP	Chronic Non-Specific Low Back Pain
EQ-5D-5L	Health-Related Quality of Life
FABs	Fear-Avoidance Beliefs
GPE	Global Perceived Effect
GRC	Global Rating of Change Scale
HIT	High-Intensity Training
HIIT	High-Intensity Interval Training
HSCL-25	25-item Hopkins Symptom Checklist
IASP	International Association for the Study of Pain
LBP	Low Back Pain
LIT	Low-Intensity Training
MIT	Moderate Intensity Training
MMPR	Multimodal Rehabilitation Programs
MODI	Modified Oswestry Disability Index
MRI	Magnetic Resonance Imaging
NM	Newton Meter
NRS	Numerical Pain Rating Scale
NPRS	Numeric Pain Rating Scale
NSCLBP	Non-Specific Chronic Low Back Pain
ODI	Oswestry Disability Index
OMT	Osteopathic Manipulative Treatment
OSW	Oswestry Questionnaire
PA	Physical Activity
PE	Physical Exercise
PNE	Pain Neuroscience Education
RDQ	Roland Disability Questionnaire

Abbreviation	Meaning
PSFS	Patient-Specific Functioning Scale
RM	Repetition Maximum
SF-36	Medical Outcome 36-item Short Form Health Survey
TSK	Tampa Scale for Kinesophobia
VAS	Visual Analogue Scale
WLC	Waiting List Control

2 Introduction

Chronic low back pain is one of the most common non-communicable diseases worldwide and a common patient presentation in osteopathic clinics. Physical activity and exercise ordinations, whilst often not the primary treatment modality used by osteopaths managing patients with chronic low back pain, may promote positive therapeutic effects in patients suffering from chronic pain. Osteopaths, physicians and therapists promote their patients to establish a physical activity and exercise routine as part of a multifactorial and holistic treatment approach. Incorporating exercise and physical activity with regards to the patients preferences, wishes, goals and resources a higher standard of patient-centred care is achieved. High-intensity training may have the ability to improve strength, disability and quality of life. Establishing if high-intensity training could be valuable as part of an osteopathic management of chronic low back pain has high clinical relevance.

3 Background

3.1 Chronic Low Back Pain

Chronic low back pain (CLBP) is classified as pain lasting 12 weeks or longer and is the leading cause of disability and the most common of all non-communicable diseases (Owen et al., 2019). The reasons for CLBP are multiple, making it difficult to establish a differential diagnosis. Specific causes for low back pain (LBP) are uncommon, around 15% of all back pain, and are defined as symptoms from the various specific pathophysiologic mechanisms such as herniated discs, infections, osteoporosis, rheumatoid arthritis, fracture, or cancer. The remaining 85% of the patients suffering from CLBP are generally referred to as having non-specific LBP (NSLBP) (Russo et al., 2017). Patients with NSLBP have been defined by having symptoms without a clear and specific cause, thus being of unknown origin. Unlike specific LBP there is no strong association with spinal abnormalities found on x-rays and magnetic resonance imaging (MRI), as these abnormalities can show up in individuals without any symptoms (van Middelkoop et al.).

Chronic low back pain is commonly localised below the costal margin and above the inferior gluteal folds, with or without referred leg pain (Owen et al., 2019). There can be a wide range of problems associated with people suffering from low back pain, these may include physical, psychological, and physiological areas of their lives (Yan et al.). Meaning that the life of a patient with chronic pain can present a daily challenge, affecting the physical, emotional, and social areas of their lives (Borisovskaya, Chmelik and Karnik, 2020). Patients that suffer from chronic pain can show psychological symptoms such as pain-related fear, depression, anxiety, and decreased quality of life. Persons living with pain respond as a unit (body, mind, and spirit) and can eventually become exhausted and present with further symptoms of insomnia, fatigue, guarding muscles, and fear of movement (kinesophobia) (Jerome, 2017).

Pain has previously been described as either nociceptive or neuropathic (Trouvin and Perrot, 2019), leading to the exclusion of many patients such as individuals with fibromyalgia or non-specific chronic low back pain; therefore, a third descriptor was needed to classify patients better. In 2017 the council of The International Association for the Study of Pain (IASP) proposed a new description for pain with no underlying lesion or disease of the somatosensory nervous system: nociplastic pain (Trouvin and Perrot, 2019). The definition of nociplastic pain is: "Pain that arises from altered nociception despite no clear evidence of actual or threatened tissue damage causing the activation of peripheral nociceptors or evidence for disease or lesion of the somatosensory system causing the pain." (International Association for the Study of Pain (IASP), n.d.). A note is added to the description stating that the patient can be affected by a combination of nociceptive and nociplastic pain (Trouvin and Perrot, 2019).

3.1.1 Chronic Low Back Pain in Sweden

The widespread problem of Low Back Pain is no exception in Sweden. 70-80% of the Swedish population are estimated to once in their lifetime develop LBP and many of these will develop Chronic Low Back Pain (SBU, 2015). Due to the high occurrence, it is a common cause of lost workdays and disability. In 2001, LBP represented 11% of the total costs for short-term leave in Sweden. The same year a total of 13% of the total granted early retirement pensions were related to back pain, where low back pain was the most critical group (Ekman, Johnell and Lidgren, 2005).

The economic burden of LBP in Sweden was estimated in 2001 to be around €1860 million, where 84% of the total cost was accounted for indirect expenses (losses to paid productivity) (Olafsson et al., 2018). The societal cost of back pain is up to three times higher than the total amount of all charges from all types of cancer (SBU, 2000).

3.1.2 Treatment approaches for Chronic Low Back Pain

Given the non-specificity of much chronic low back pain and the complex multifactorial aetiology, treatment approaches vary widely and often include multiple interventions across different modalities including pharmacology, manual therapy, psychotherapy, exercise and others. A review of europe-wide guidelines for management of acute and chronic low back pain recommended the use of NSAIDs alone or together with antidepressants when low back pain accompanied depression (Oliveira et al., 2018). A pharmacological treatment is recommended if first-line therapy is unsuccessful and often includes NSAIDs, opioids, paracetamol, and muscle relaxants (Thompson et al., 2020). Non-pharmacological approaches include manual therapy, exercise, weight loss, massage, yoga, acupuncture, tai chi, mindfulness and meditation (Jerome, 2017). Surgery is considered in patients with functional disabilities but it has been shown that most patients with chronic low back pain do not benefit from surgery (Last and Hulbert, 2009). The use of laboratory tests, x-rays and magnetic resonance imaging (MRI) should only be used where a serious condition is suspected or where findings will likely change management approach (Foster, 2018).

Chronic pain self-management should be an active, collaborative relationship between the patient and the osteopath, with shared goals of the patient's pain management (Jerome, 2017). Osteopaths encourage their patients to become actively responsible for their self-management and take day-to-day action for all aspects of their lives that are affected by their symptoms; these include their pain, feelings, beliefs, attitude, social and emotional life, as well as their social, cultural, or religious environments (Jerome, 2017).

Musculoskeletal healthcare models traditionally focus heavily on biomedical factors. Focusing on anatomy, biomechanics, and pathoanatomy, aiming to explain pain to patients through a tissue-specific perspective. This may be clinically more applicable in acute injuries, surgery or disease states but this model lacks the ability to explain the complexity of chronic pain and therefore has a limited effect in decreasing pain and disability, fear, anxiety and stress (Louw et al., 2016).

A biopsychosocial model is an approach of osteopathic care that addresses biological, psychological and social aspects of the patient (Engel, 1977). This approach requires the osteopath to have some knowledge and understanding of these different factors in the patient presentation. Reflecting this, multimodal rehabilitation programs (MMPR) are evidence-based multidisciplinary biopsychosocial rehabilitation programs offered worldwide to patients with chronic pain conditions (Svanholm et al., 2020). MMPR is a well-coordinated intervention and is distinguished by a complex intervention instead of a single treatment. This generally includes education, physical activity under supervision, training in inspiring environments and cognitive behavioural therapy (Gerdle et al., 2019) delivered by professionals with various clinical qualifications and history (Svanholm et al., 2020).

The involvement of a mind-based therapy such as cognitive behavioural therapy seems to be beneficial as part of a multimodal approach to chronic low back pain, and is strongly supported by existing research. Pain-coping behaviours are taught through diaphragmatic breathing, muscle relaxation, distraction techniques, activity pacing, problem solving, sleep, hygiene and stress management (Jerome, 2017). Fear avoidance behaviours are seen as an important risk factor for CLBP, so it is important to address these as part of a holistic approach (Yan et al., 2021) and CBT may also decrease catastrophising and increasing self-efficacy characteristically seen in chronic pain patients. Mindfulness-based therapies may also benefit these patients and aid pain acceptance (Turner et al., 2016). Patients will more effectively solve problems related to their pain and commence changes in their behaviour (Crofford, 2015).

The growing body of evidence supports that there are changes in brain structure, function, and chemistry happening in patients with chronic low back pain. These changes contribute to central sensitisation, which appear responsible for increased pain sensitivity and referred pain. Research shows that not all patients with chronic low back pain are troubled by central sensitisation. Therefore both bottom-up and top-down mechanisms are at play in patients with chronic pain (Bid, Soni and Rathod, 2011). Pain neuroscience education (PNE) is a cognitive-based education (Louw et al., 2011) that utilises this understanding by explaining some of the processes and representation of pain to the patient. This addresses and may modify some of the prior existing beliefs or expectations that may influence pain experience and symptomatology (Louw et al., 2016) aiming at decreasing the sensitivity of the central nervous system (Nijs et al., 2015). Studies show great benefit of using PNE in chronic pain patients (Louw et al., 2011). The combination of PNE, manual therapy and supervised exercise suggests to be more effective than an education-only approach (Puentedura and Flynn, 2016).

3.1.3 Chronic Low Back Pain in the field of Osteopathy

Osteopathy is a manual therapy that focuses on the musculoskeletal system and promotes health and function and involves a broad variety of techniques (Franke, Franke and Fryer, 2014). The underlying approach of osteopathy is based on three principles: the person is a dynamic, functional unit; structure and function are interrelated; the body has self regulatory and self-healing mechanisms (Stark 2013).

Low back pain is one of the most common patient presentations in osteopathic clinics, although the number of patients seeking help from an osteopath for LBP is unclear (Franke, Franke and Fryer, 2014). In the United Kingdom, lumbar symptoms are the most common presentation in osteopathic clinics. In a national pilot survey and a snap-shot survey, the patients seeking help for their low back pain accounted for 36% and 46%, respectively. In Australia, the osteopathic profession is relatively small, and only 2.7% of the patients seeking help for their low back pain choose to see an osteopath. In the United States, osteopaths are osteopathic physicians and hold a full medical licence, making them more likely to provide help for patients with LBP than their allopathic medical counterparts (Franke, Franke and Fryer, 2014).

Osteopathic manipulative treatment (OMT) involves various manual techniques that include soft tissue stretching, joint manipulations, muscle energy techniques, myofascial release, craniosacral treatment, and visceral manipulations. These methods can be applied individually or in combination with each other. Osteopathic treatment is defined by a whole-body approach, treating many body regions and sometimes indirectly to the symptomatic area. The therapeutic aim is to improve physiological function in patients with somatic dysfunction and support their body’s homeostasis (Dal Farra et al., 2021). Techniques that show positive short-term effects used by osteopaths are joint mobilisation with and without thrust, soft-tissue mobilisation and exercise ordination (George et al., 2021).

A study by Licciardone et al. (2016) shows that 20-25% of the patients that received OMT experienced improvements in pain intensity and disability. The best results are presented with patients who experience moderate to severe pain levels and back dysfunction. In a meta-analysis done by Dal Farra et al. (2021), seven out of ten studies were able to show significant improvements in both pain and disability after osteopathic interventions using OMT, myofascial release and craniosacral treatment in patients with chronic low back pain (Dal Farra et al., 2021).

Implementing exercise in the treatment might help correct structural disturbances and encourage the patient's inherent ability to heal. According to A. T. Still: “The human body is a perfect machine created for health and activity” (Seffinger et al., 2011:11). As an osteopath, the emphasis lies on health restoration and disease prevention, and this includes addressing regular aerobic, stretching and strengthening exercises (Seffinger et al., 2011). In the updated Clinical Practice Guidelines linked to the International Classification of Functioning, Disability and Health (George et al., 2021), the recommendations for patients with chronic low back pain advocate the use of exercise training interventions. In addition to manual and active treatments, therapists should include standard education strategies such as advice related to exercise and staying active. The practitioner should also deliver pain neuroscience education alongside the other treatment interventions (George et al., 2021).

Osteopaths use pain education to help patients improve the connection between body and mind and reframe pain. Aiming to de-threaten and guide the patient in understanding their multifactorial pain (Abrosimoff and Rajendran, 2019). This is an that is able to interact with top down factors, shifting perception and establishing a change in the central nervous system. Osteopaths incorporate modalities such as mindfulness, acceptance-commitment therapy and educational interventions, these show positive outcomes and are found to improve patient cognition, decreasing fear and reducing pain (Abrosimoff and Rajendran, 2019). Treating somatic manifestations of stress and chronic pain with mindfulness practices are seen as a viable complement for manual therapy. Research shows promising results in combining mindfulness-based interventions with manual therapy delivered by osteopaths (Casals-Gutiérrez and Abbey, 2016).

3.2 Physical activity and exercise

Caspersen et al. (1985) defined physical activity as “any bodily movement produced by the skeletal muscles that results in energy expenditure” (Caspersen, Powell and Christenson, 1985:126). Physical activity (PA) in daily life can be put into different categories such as occupational, sports, conditioning, household, or other activities. Physical activity can be divided into activities with different levels of intensity and intentional or obligatory. However, physical exercise (PE) is a planned, structured and repetitive physical activity with the goal to improve or maintain physical fitness. Both PA and PE involve any bodily movement that is produced by skeletal muscles and that expends energy. Physical fitness has been defined as “the ability to carry out daily tasks with vigour and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies" (Caspersen, Powell and Christenson, 1985:128). Physical fitness describes a set of character qualities that people either have or achieve (Caspersen, Powell and Christenson, 1985). Components of physical fitness that can be worked on are an increase in muscular strength, the cardiorespiratory capacity, and body composition (Lundqvist, 2020).

The internationally recommended level of physical activity (PA) is at least 150 min of moderate-intensity PA or 75 min of vigorous-intensity PA per week or any combination of the two. Muscle-strengthening PA should be added ≥2 times/week and should involve major muscle groups, and for those aged 65 and over, balance training and fall prevention should be performed ≥3 times/week. Individuals that are elderly have chronic illnesses or disabilities that can not achieve these recommendations should be as active as their condition possibly allows them to be (Lundqvist, 2020).

Physical exercise has the ability to improve general health, decrease the risk and progression of chronic illnesses such as cardiovascular disease, type-2 diabetes, and obesity. Physical inactivity may contribute to the rise of chronic diseases. The World Health Organisation (WHO) and the Centers for Disease Control and Prevention (CDC) target physical inactivity as the leading risk factor in non-communicable diseases and death worldwide. A tool for primary and secondary prevention of chronic disease is regular physical exercise, shown to have the ability to alleviate symptoms and hinder or halt disease progression (Ambrose and Golightly, 2015). In addition to disease prevention, physically active individuals are shown to sleep, feel, and function better. Physical activity can also help improve mental health, quality of life, and well-being (Lundqvist, 2020).

The Public Health Agency of Sweden reported in 2019 that 36% of all Swedish adults were insufficiently physically active, with no significant differences between men and women. Physical activity (PA) level was lowest amongst older adults, citizens with less education and lower socioeconomic positions and people living in rural areas. Sedentary time was higher in men (50%) than in women (44%), notably higher in younger adults with a higher level of education and amongst people living in urban areas (Lundqvist, 2020).

Barriers that can be encountered and reported by patients prescribed with physical activity as a treatment are: time constraints, psychological/perceived negative feelings, transport/venue problems, unwell, inadequate support, and financial constraints (Lundqvist, 2020).

3.2.1 Physical exercise and chronic pain

Clear guidelines for physical activity are lacking for individuals with chronic pain, but frequent movement is favoured to a sedentary lifestyle. This gives the therapist or physician considerable freedom in programming an exercise protocol tailored to the needs, interests, and resources of the patient (Ambrose and Golightly, 2015).

The overall health benefits of physical activity are indisputable, irrespective of whether the physical activity is performed at a low or high intensity. There is no single exercise modality that provides overwhelming symptom relief for chronic pain patients, but physical activity is consistently supported in alleviating chronic pain, cognitive and physical function, sleep patterns, and global health (Ambrose and Golightly, 2015).

Chronic non-specific musculoskeletal pain management often combines physical exercise and cognitive behavioural therapy as a primary treatment in chronic low back pain and fibromyalgia. Physical exercise can include a variety of interventions such as walking, running, aerobic and aquatic exercises, dancing, and cycling (Bergman, 2007). A preparation phase with intensive pain neuroscience education is recommended and maybe even required before initiating any exercise therapy for individuals with chronic musculoskeletal pain. The patient's perception about specific exercises should be addressed and challenged to discover the nature and reason for their fears. Simultaneously the therapist should assure the safety of the exercises to increase confidence and decrease anticipated danger. Integrating pain neuroscience education and physical exercise creates the opportunity to implement a graded exposure (Nijs et al., 2015).

Research shows that resistance training performed at a 70-85% repetition maximum (RM), three times per week for 20 minutes, effectively reduces pain in the shoulders, wrists, cervical, dorsal and lumbar spine in work-related musculoskeletal disorders (Rodrigues et al., 2014).

3.3 High-intensity training

It is suggested that the use of interval training started sometime around 1912, but did not achieve popularity until the beginning of the 1950's. High intensity training gained popularity after triple gold Olympic champion, Emil Zátopek from Czechoslovakia, shared his training (Laursen and Buchheit, 2019).

High-intensity training is characterised by repetitive short to long bouts of exercise performed under high intensity, alternated with periods of low intensity or rest (Ross, Porter and Durstine, 2016). The intensity of the active period should lie around 75-90% of maximal performance and the recovery periods around 40-70%, this varies between literature (Karlsen et al., 2017; Ross, Porter and Durstine, 2016).

High-intensity training can be tailored to the patient's individual needs and can be applied to many different exercise settings. This ability to individualise the exercise program to meet the patients outcome goals makes it a valuable tool for patients with chronic diseases (Ross, Porter and Durstine, 2016).

3.3.1 High-intensity training and chronic diseases

When a person with chronic disease starts to become less active, a cycle of deconditioning can be triggered, this may lead to a loss of functional ability and a reduction in the ability to perform activities and exercises in their daily life. The consequences of deconditioning is poor long-term health and a significant loss of quality of life, meaning that this cycle should be stopped as quickly as possible. To stop this cycle, individuals with chronic disease should receive proper counselling around the safety, effectiveness, and proper use of physical activity and prescribed exercise (Ross, Porter and Durstine, 2016).

Cardiovascular disease is the most studied chronic disease regarding the potential benefits of using HIIT protocols as a treatment modality. Less studied are the applications of similar HIIT protocols for patients with pulmonary disease and type 2 diabetes (Ross, Porter and Durstine, 2016).

Studies suggest that utilising high-intensity training (HIT) for patients with heart disease creates a significant improvement in aerobic capacity adaptations compared to a moderate approach without increasing medical risks. Present data suggest that HIT can effectively improve functional capacity, endothelial function and lower C-reactive protein blood levels (Ross, Porter and Durstine, 2016). In addition, HIT indicates to induce greater cardioprotective effects than exercise on a moderate intensity (Karlsen et al., 2017).
High-intensity training can therefore be advised in the management of patients with chronic diseases (Ross, Porter and Durstine, 2016).

4 Research question and aim

One of the most common patient representations in osteopathic clinics are patients suffering from low back pain (LBP) that commonly progresses into chronic low back pain (CLBP) (Franke, Franke and Fryer, 2014). As the number of people going to experience LBP and CLBP is unlikely to decrease, researching the best approach to treat these patients is highly relevant (SBU, 2015). A multimodal approach of treating patients with CLBP is regarded as the best treatment method, as a combination of pharmacological and non-pharmacological management strategies appears to be most effective (Ambrose and Golightly, 2015).

High-intensity training is shown to be a beneficial treatment approach for a number of chronic diseases when incorporated into a multimodal treatment approach (Ross, Porter and Durstine, 2016). Exercise recommendations are commonly used in osteopathic clinics and an essential addition to manual therapy.

The purpose of this study is therefore to compare existing research on the efficiency of using high-intensity training as a treatment method in osteopathic management in adult patients suffering from chronic low back pain. The research question is:

Is high-intensity training an effective treatment approach for adult patients suffering from chronic non-specific low back pain?

5 Methodology

This study has taken the form of a literature review. An initial search was performed on two electronic databases, PubMed and Science Direct, to determine the feasibility of this project. After establishing a scope of the field of exercise as a treatment modality for chronic pain, through reading reviews and systematic reviews on the matter, there seemed to be enough research on the use of physical exercise for the treatment of CLBP. The majority of the exercise used to treat people that suffer from CLBP appeared to be low-intensity training, motor control exercises or stabilising exercises, and remarkably little was encountered on the use of high-intensity training (HIT) and high-intensity interval training (HIIT).

5.1 Search strategy

To be sure the most accurate search strings with the highest accuracy were used, a librarian at the Biomedical Library from Gothenburg University was consulted, and a search strategy was developed using the following keywords and MeSH terms.

Table 2. List of Mesh terms and search strings.

MeSh terms
High-intensity interval training, “high intensity interval training”, “high-intensity training”, “high intensity training, “high intensity resistance training, HIT, HIIT, “high-intensity intermittent exercise, “sprint interval training, “low back, “lower back, lumbago, low back pain, chronic low back pain.
Search strings
(High-intensity interval training OR "High intensity interval training" OR "High-intensity training" OR "high intensity training" OR "high intensity resistance training" OR HIT OR HIIT OR "High-Intensity Intermittent Exercise" OR "Sprint interval training") AND ("Low Back" OR "Lower Back" OR Lumbago OR Low Back Pain)
(chronic low back pain) AND ("high-intensity interval training" OR "high-intensity training" OR "strength training")
(chronic low back pain) AND ("high-intensity interval training" OR "high-intensity training" OR "strength training")

5.2 Inclusion and exclusion criteria

The initial period that was assessed and amended in order to to include two relevant articles. The original publication period was set from 2018 to 2021, including just the latest relevant research. With the lack of research papers and having two papers published in 2004 and 2008, the period for publication was prolonged from 2004 to 2021.

Table 3. List of inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Articles that are written between 2004 - 2021	Research participants with pathology or specific cause responsible for their chronic low back pain
Articles with a score of at least 6/10 on the PEDro scale	Research participants that have undergone surgery as a treatment for chronic low back pain
Articles that offer a full text version	Research participants that are younger than 18
Articles that are written in English	Research participants that are pregnant
Research trials have been conducted on humans	Research that combines high-intensity interval training with another treatment method
Research trials that have participants of the age of 18 or older	Systematic reviews, review articles, meta-analyses, and non-randomized clinical trials will be excluded
Research that uses high-intensity interval training as a primary treatment method	Articles that require payment for access

5.3 Literature research

A search on two electronic databases, PubMed and CINAHL was performed. The aim was to find randomised clinical trials that met all of the inclusion and exclusion criteria. The search on both databases resulted in 187 articles and after applying all of the inclusion and exclusion criteria a total of 20 articles remained. Removing duplicates, a final amount of 5 articles were selected for further analysis.

The quality of the articles was evaluated using the PEDro scale, where 10 out of 11 points are counted. The PEDro scale was developed to help users identify trials that are expected to be credible and have satisfactory statistical information to help guide decision-making. For this review, a score of 6 was regarded as the lowest acceptable score for inclusion.

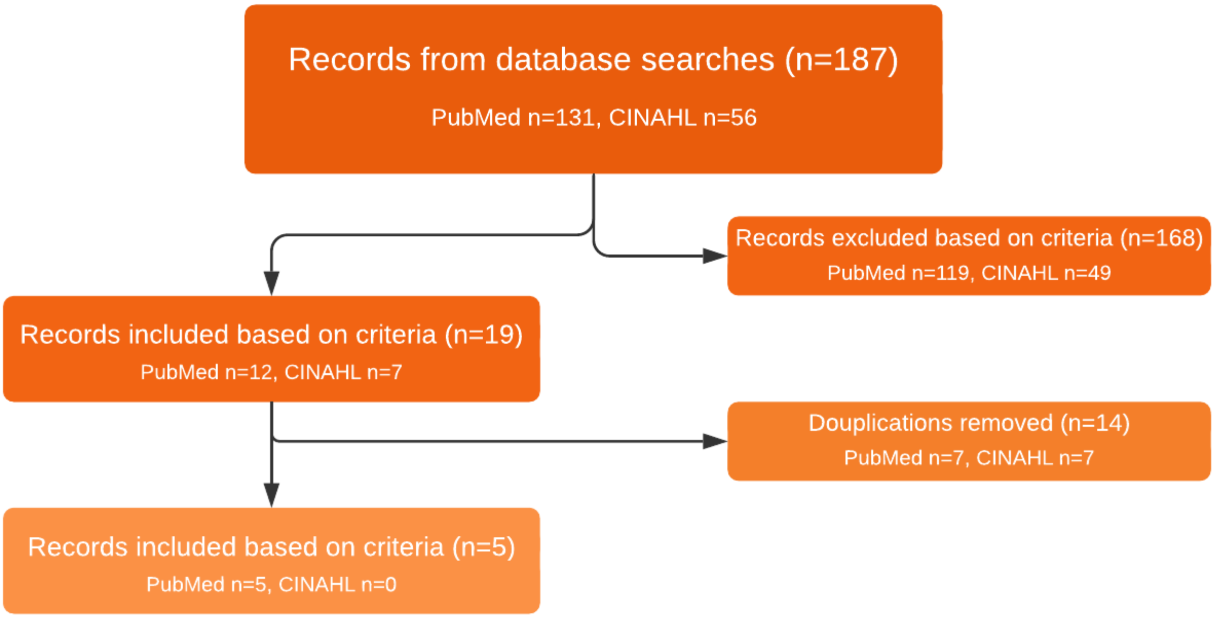

Figure 1. Research flow chart. Illustrating the process of inclusion and exclusion based on criteria.

5.4 Final inclusion

The final five articles were reviewed and analysed in-depth. The key information such as study design, outcome measures, and the results of the individual studies was extracted (Table 5). The results from these five articles were then analysed and compared to each other to draw any potential conclusions. The analysis included the study design, outcome measures, and results, respectively.

6 Results

6.1 Overview of included articles

Five articles were included in this analysis, the overview of article information is shown in Table 4. Key information of the individual studies such as study design, intervention, outcome measures and results are presented in Table 5.

Table 4. Overview of article information.

#	Author, Title and Publication Year	PEDro
1	**Harts, C.C., Helmhout, P.H., de Bie, R.A. and Bart Staal, J. (2008)** *Australian Journal of Physiotherapy* A high-intensity lumbar extensor strengthening program is little better than a low-intensity program or a waiting list control group for chronic low back pain: a randomised clinical trial	8/10
2	**Helmhout, P.H., Harts, C.C., Staal, J.B., Candel, M.J.J.M. and de Bie, R.A. (2004)** *European Spine Journal* Comparison of a high-intensity and a low-intensity lumbar extensor training program as minimal intervention treatment in low back pain: a randomised trial	7/10
3	**Verbrugghe, J., Agten, A., Stevens, S., Hansen, D., Demoulin, C., O. Eijnde, B., Vandenabeele, F. and Timmermans, A. (2019)** *Medicine & Science in Sports & Exercise* Exercise Intensity Matters in Chronic Nonspecific Low Back Pain Rehabilitation	7/10
4	**Verbrugghe, J., Hansen, D., Demoulin, C., Verbunt, J., Roussel, N.A. and Timmermans, A. (2021)** *International Journal of Environmental Research and Public Health* High Intensity Training Is an Effective Modality to Improve Long-Term Disability and Exercise Capacity in Chronic Nonspecific Low Back Pain: A Randomised Controlled Trial	7/10
5	**Iversen, V.M., Vasseljen, O., Mork, P.J., Gismervik, S., Bertheussen, G.F., Salvesen, Ø. and Fimland, M.S. (2018)** *Scandinavian Journal of Medicine & Science in Sports* Resistance band training or general exercise in a multidisciplinary rehabilitation of low back pain? A randomised trial	6/10

Table 5. Overview of key information from the studies.

EQ-5D-5L: Health-related quality of life, **CNSLBP:** Chronic Non-Specific Low Back Pain, **FABQ A:** Fear Avoidance Beliefs Questionnaire in relation to physical activity, **FABQ B:** Fear Avoidance Beliefs Questionnaire in relation to work, **FU:** Follow Up, **GPE:** Global perceived effect, **GRC:** Global Rating of Change Scale, **HSCL-25:** 25-item Hopkins Symptom Checklist, **MODI:** Modified Oswestry Disability Index, **NRS:** Numerical Pain Rating Scale, **NPRS:** Numeric Pain Rating Score, **NSLBP:** Non-Specific Low Back Pain, **ODI:** Oswestry Disability Index, **OSW:** Oswestry Questionnaire, **PSFS:** Patient-Specific Functioning Scale, **RDQ:** Roland Disability Questionnaire, **SF-36:** Medical Outcome 36-item Short Form Health Survey, **TSK:** Tampa Scale for Kinesophobia, **WAI:** Work Ability Index

#	Study design & Subjects	Intervention	Outcome measures & results
1	RCT 8-week program - 10 training sessions Measured at baseline, week 8 (post) and week 24 (FU) Randomised (n=65) HIT (n=23) LIT (n=21) WLC (n=21) All male, 18+, Army CNSLBP	**HIT:** progressive, high-intensity resistance exercise program of the lumbar extensors **LIT:** non-progressive, low-intensity resistance exercise program of the lumbar extensors **WLC:** received no intervention during the first 8 weeks, then got randomised into either HIT or LIT group	**GPE:** Significant increase/improvement in HIT (39%) compared to WLC and LIT in week 8. Significant increase/improvement within the LIT group between week 8 and 24 (35%). Non-significant improvement in HIT between week 8 and 24. **RDQ:** Non-significant decrease/improvement within HIT and LIT at week 24, (-2.5 and -4.5 points) compared to baseline. No significant change between the groups. LIT had a greater improvement between post and FU compared to HIT. **SF-36:** Significant improvement in HIT (7%) compared to LIT (3%) in week 8 and within HIT (10%) at week 8, LIT (4%). At 24 weeks both groups had a 6 % improvement compared to baseline which means no difference between groups. HIT stayed the same between post and FU, LIT kept on improving. **TSK:** Non-significant improvements in both groups. No significant change between the groups. HIT continued improvement between post and FU, LIT stayed the same. **Strength - back:** Non-significant increased strength within HIT and LIT at week 24 compared to baseline. HIT greater improvement between post and FU than LIT.
2	RCT 12-week program - 10 training sessions Measured at baseline, 1m, 2m, 3m (post), 6m (FU), and 9m (FU) Randomised (n=81) HIT (n=41) LIT (n=40) All male, 18+, Army CNSLBP	**HIT:** progressive, high-intensity resistance exercise program of the lumbar extensors **LIT:** non-progressive, low-intensity resistance exercise program of the lumbar extensors	**GPE:** Non-significant between-group difference: HIT group improved 12% more than LIT group at 3m (post) and 13.2% at 9m (FU). Non-significant improvements in both HIT and LIT at post and FU. **RDQ:** Non-significant improvement in both groups. At 9 months FU both HIT and LIT had the same score. LIT improved greatly. **OSW:** Non-significant improvement in both groups. HIT improved greatly. **TSK:** Significant decrease/improvement in LIT group in months 2 and 9 compared to HIT group, a between-group difference of 2.5 points (2m) and 3.4 points (9m). Non-significant improvement in the HIT group. **SF-36:** Non-significant improvement either within or between the groups. LIT group improved more than the HIT group. **Strength - back:** HIT group significant increase at 6m and 9m (24-58nm) compared to LIT. Non-significant strength increase in LIT.
3	RCT 12-week program - 24 training sessions Measured at baseline and week 12 (post) No follow-up Randomised (n=100) Allocated to other groups (n=61) HIT (n=19) 6m, 13f MIT (n=19) 6m, 13f 25-60, CNSLBP	**HIT:** cardiorespiratory training, general resistance training, and core muscle training, all at a high-intensity **MIT:** cardiorespiratory training, general resistance training, and core muscle training, all at a moderate intensity	**MODI:** Significant decrease in both HIT group and MIT group (pre vs. post). HIT group improved significantly more than the MIT group (-8.6%) pre vs. post. **NPRS:** Significant decrease in both HIT group and MIT group (pre vs. post, HIT: -3.2. MIT: -2.2). No significant difference between groups. **PSFS:** Significant increase/improvement in both HIT group and MIT group (pre vs. post, 26% in both groups). No significant difference between groups. **VO2max:** Significant decrease in both HIT and MIT (pre vs. post). Significant difference between HIT and MIT (3.1mL·kg−1·min−1). **Max workload:** Significant decrease in both HIT and MIT (pre vs. post, HIT: 2.7 min, MIT: 1.7 min). Significant difference in favour of HIT. **Strength - back:** Significant increase in both HIT and MIT (pre vs. post, HIT: 10%, MIT: 13%). No significant difference between groups.

#	Study design & Subjects	Intervention	Outcome measures & results
4	RCT 12-week program - 24 training sessions Measured at baseline, week 12 (post), and 6 months (FU) Randomised (n=100) Allocated to other groups (n=62) HIT (n=19) 6m, 13f MIT (n=19) 6m, 13f 25-60, CNSLBP	**HIT:** cardiorespiratory training, general resistance training, and core muscle training, all at a high-intensity **MIT:** cardiorespiratory training, general resistance training, and core muscle training, all at a moderate intensity	**MODI:** Significant decrease/improvement in both HIT and MIT (pre vs. FU, HIT: 62% improvement, MIT: 36% improvement). Significant decrease in HIT compared to MIT (pre vs. FU) **NPRS:** Significant decrease/improvement in both HIT and MIT (pre vs. FU, HIT: 59% improvement, MIT: 54% improvement). MIT significant improvement, post vs. FU. No significant difference between groups. **PSFS:** Significant increase/improvement in both HIT and MIT (pre vs. FU, HIT: 54%, MIT: 68%). No significant further improvement (post vs. FU). No significant difference between groups. LIT improved more than HIT overall. **VO2max:** Significant decrease in HIT compared to MIT (pre vs. FU, HIT: 10% improvement). No significant further improvement (post vs. FU). Significant difference between groups (pre vs FU) in favour of HIT (3.2 mL/kg/min). **Strength - back:** Significant increase in HIT (pre vs. post, 0.25Nm/kg), not maintained until FU. Significant increase in MIT (pre vs. FU, 0.34Nm/kg). No significant difference between groups.
5	RCT 12-week program - 9 vs. 36 training sessions Measured at baseline and week 12 (post) No follow-up Randomised (n=99) General Physical Exercise (MIT) (n=49) (54% female) High-intensity training (HIT) (n=50) (59% female) 16-70, CNSLBP	**MIT:** 9 sessions under supervision and a home-based program, not defined. **HIT:** 9 sessions under supervision and 27 sessions with a progressive increase as a home-based program.	**ODI:** Significant improvement in both MIT and HIT (baseline vs. 12 weeks). No significant difference between groups. **NRS:** Strong significant improvement (P = .01) in MIT (baseline vs. 12 weeks, -1.2 points) compared to HIT (-0.6). Non-significant improvement in MIT (pre vs. post). No significant difference between groups. **WAI:** Strong significant improvement (P = .01) in both MIT and HIT (baseline vs. 12 weeks, MIT: -1.3 points, HIT: -1.2 points). No significant difference between groups. **HSCL-25:** Strong significant improvement in both MIT and HIT (P = .01) (baseline vs. 12 weeks, MIT: -0.28 points, HIT: -0.18 points). No significant difference between groups. **EQ-5D-5L:** Non-significant improvement in both groups. HIT improved greater. **FABQ A:** Strong significant improvement (P = .01) in both MIT and HIT (baseline vs. 12 weeks, MIT: -2.5 points, HIT: -2.3). GPE improved greater. No significant difference between groups. **FABQ B:** Non-significant improvement in both groups. HIT improved greater. **GRC:** Non-significant improvement in both groups. MIT improved greater. **PSFS:** Strong significant improvement (P = .01) in both MIT and HIT (baseline vs. 12 weeks, MIT: -2.8 points, HIT: -1.4 points). Significant decrease in MIT compared to HIT (baseline vs. 12 weeks, 1.4 points difference) **Strength - back:** Significant increase in MIT (baseline vs. 12 weeks, 77Nm). Strong significant increase (P = .01) in HIT (baseline vs. 12 weeks, 153Nm). No significant difference between groups.

6.3 Study population

The number of subject numbers in the five studies ranged from between 38-81 participants. Iversen et al. (2018) had the biggest inclusion criteria when it came to age in their study, with an age range between 16-70. Comparing this to the other studies analysed, the age range was set to either 18-54 or 25-60. The mean percentage of women across the studies is 39%, although, in 3 studies, this number is significantly higher, ranging between 57 - 69% (Iversen et al., 2018; Verbrugghe et al., 2019; Verbrugghe et al., 2021).

All studies compared high-intensity training (HIT) to another form of exercise, either low or moderate intensity training (LIT/MIT). Harts et al. (2008) had a Waiting List Control group

(WLC), although only for the first eight weeks of the intervention, the participants of the WLC group were then randomised into either the HIT or LIT group. The other studies had a similar study design, with two groups, either high-intensity training (HIT) or a low/moderate intensity training (LIT/MIT). The effect of these interventions was then compared to each other.

Intervention time was overall similar, ranging from 8 weeks (Harts et al., 2008) until 12 weeks (Helmhout et al., 2004; Iversen et al., 2018; Verbrugghe et al., 2019; Verbrugghe et al., 2021) in the research studies that were analysed. The general approach included 1-2 training sessions per week (Harts et al., 2008; Helmhout et al., 2004; Verbrugghe et al., 2019; Verbrugghe et al., 2021), whereas Iversen et al. (2018) had different amounts of training sessions per week for their study groups. The moderate-intensity training (MIT) group received four sessions in the first week of intervention and five sessions in week three and were thereafter encouraged to do a home-based program, the high-intensity training (HIT) group on the other hand had a steady routine of 3 sessions per week. The number of interventions varied widely. Iversen et al. (2018) had the most extensive difference of supervised interventions, nine to 36 sessions. Both of their intervention groups received nine supervised sessions, the MIT group were thereforth encouraged to do their personalised general physical activity home-based program as much as possible, whereas the HIT group got the direction to undertake their home-based high-intensity elastic band program 3 times per week. Harts et al. (2008) and Helmhout et al. (2004) provided ten intervention sessions and Verbrugghe et al. (2019, 2021) 24 sessions.

Three out of five articles had follow-up measurements (Harts et al., 2008; Helmhout et al., 2004; Verbrugghe et al., 2021). Harts et al. (2008) had a 16-week follow-up, Helmhout et al. (2004) had two follow-up measurements, 12 weeks and 24 weeks respectively; also, Verbrugghe et al. (2021) used a 12 week follow-up time.

6.4 Effects of intervention

6.4.1 Disability

Throughout the five final research articles, disability was the one pervading primary outcome that was measured using a variety of different methods of measuring disability: Roland Disability Questionnaire, Oswestry Questionnaire, Oswestry Disability Index, Modified Oswestry Disability Index.

Three studies (Iversen et al., 2018; Verbrugghe et al., 2019; Verbrugghe et al., 2021) showed a significant improvement in all intervention groups indicating that both high and medium intensity exercise is beneficial in improving disability but there was no significant effect of the exercise intensity. However, two studies (Verbrugghe et al., 2019; Verbrugghe et al., 2021) showed a significantly better effect in the high intensity training (HIT) group compared to the medium intensity training (MIT) group. The HIT group in Verbrugghe et al. (2021) study had a slight setback between end of intervention and 3 month follow up, although still a greater improvement than the MIT group.

Harts et al. (2008) showed that there was a greater improvement in the low-intensity training (LIT) group, measured at the 16 weeks follow up, compared to the high intensity training (HIT) group, but the improvement was not strong enough to be significant. Neither could they prove that the difference between the two groups was significant.

Helmhout et al. (2004) had non-significant improvements in both intervention groups (HIT/LIT) with a greater overall improvement in the low-intensity training (LIT) group. Still, when comparing the scores of the two intervention groups at the six months measurement point (24 weeks), there was no significant difference between the groups.

6.4.2 Pain

Three out of five articles (Iversen et al., 2018; Verbrugghe et al., 2019; Verbrugghe et al., 2021) measured pain as an outcome measure in their research.

The three articles that measured pain show an improvement in all intervention groups. Two out of three (Verbrugghe et al., 2019; Verbrugghe et al., 2021) significantly improved both their research groups, high and moderate intensity training (HIT and MIT), from PRE to POST. In Verbrugghe et al. (2021) study, the MIT group continued to improve after intervention, resulting in a significant improvement between post intervention and follow up at 3 months. The HIT group had additional improvements between the end of intervention and follow up, but not significant. In the article by Iversen et al. (2018), moderate-intensity training (MIT) group had a very significant improvement from baseline to after intervention, with a p-value of 0.01, resulting in a significant difference compared to the improvement of the HIT group.

6.4.3 Kinesophobia

Two articles measured their outcome with the Tampa Scale of Kinesophobia (TSK) (Harts et al., 2008; Helmhout et al., 2004), one article measured their outcome with the Fear Avoidance Beliefs Questionnaire (FABQ) (Iversen et al., 2018) and two articles did not measure any fear or movement or (re)injury (Verbrugghe et al., 2019; Verbrugghe et al., 2021).

Harts et al. (2008) did not measure any significant improvements in Tampa Scale of Kinesophobia (TSK), although the high-intensity training (HIT) group kept on improving after intervention until follow-up. Helmhout et al. (2002) got a significant improvement both within the low-intensity training (LIT) group and between the groups favouring LIT. The HIT group improved but not significantly.

Iversen et al. (2018) measured their outcomes with Fear Avoidance Beliefs Questionnaire (FABQ A/B), looking at the fear-avoidance to physical activity and work, showing a significant improvement from baseline to after intervention in FABQ A in moderate and high-intensity training (MIT/HIT) with a greater improvement in the MIT group and no significant improvement in FABQ B but with a greater improvement in the HIT group.

6.4.4 Quality of life

There was a wide range of how the five included studies measured patient functioning and global change.

Patient-Specific Functioning Scale (PSFS) was the measuring tool used by three articles. These three articles (Iversen et al., 2018; Verbrugghe et al., 2019; Verbrugghe et al., 2021) got a similar result where the high and moderate intensity training (HIT/MIT) group improved significantly from baseline to after intervention. In addition, Iversen et al. (2018) measured a strong significant difference ($P = .01$) between the moderate and high-intensity training (MIT/HIT) group, where the MIT group had a greater improvement from baseline to after intervention.

Harts et al. (2008) and Helmhout et al. (2004) used the Medical Outcome 36-item Short Form Health Survey (SF-36) to measure the improvement in their participants. Harts et al. (2008) measured a significant difference between the high-intensity training (HIT) group and the waiting list control (WLC) group and within the HIT group after intervention. This improvement evened out, and at follow up 16 weeks later the improvement in both groups measured 6% each. Helmhout et al. (2004) used the same health survey and did not measure any significant change between the groups. Both the high and low intensity training group improved and at the six month follow up the group difference was 0.7% in favour of the HIT group.

The same research groups that used SF-36, in addition, measured a Global Change Rate (GPE). Harts et al. (2008) got a significant correlating improvement between the high-intensity training (HIT) group and the waiting list control (WLC) group at the end of treatment, where the HIT group improved more remarkably than the WLC group. After intervention, the change of the HIT group kept on improving but not as great as the low-intensity (LIT) group that had a significant change between end of treatment and follow-up 16 weeks later. Helmhout et al. (2004) measured an improvement in both the HIT and LIT groups from baseline to 6 months follow up, with a greater improvement in the HIT group, although none of them was considerable enough to be significant.

Iversen et al. (2018) had the widest variety of questionnaires to measure similar findings. The only research group that used the Global Rating of Change Scale (GRC) and 25-item Hopkins Symptom Checklist (HSCL-25). The GRC scale showed no significant improvement in either of the groups, although a greater improvement in the moderate-intensity training (MIT) group was clear. The HSCL-25 had a strong significant change in both groups, measuring $P = .01$, in both the moderate and high-intensity training group, in favour of MIT, with no significant difference between the two groups.

6.4.5 Strength

Strength was measured in some way in all five articles. The standard measurement in all five articles was back strength, but also abdominal strength (Verbrugghe et al., 2019; Verbrugghe et al., 2021) and grip strength (Iversen et al., 2018) were measured. This study focused on back strength as this was a standard measurement throughout all five articles.

A significant increase in back strength in the high-intensity training (HIT) group was noted in four articles (Helmhout et al., 2004; Iversen et al., 2018; Verbrugghe et al., 2019; Verbrugghe et al., 2021). The result standing out the most in these three is measured in Iversen et al. (2018) research, where the HIT group presented an improvement with $P = .01$ from baseline to after intervention. The moderate-intensity training (MIT) group had a significant improvement in three articles (Iversen et al., 2018; Verbrugghe et al., 2019; Verbrugghe et al., 2021). Iversen et al. (2018) and Verbrugghe et al. (2018) were measured from baseline to after intervention and Verbrugghe et al. (2021) baseline to the 3 months follow-up. In the research done by Verbrugghe et al. (2019), both intervention groups, (HIT/LIT), had a significant increase of strength, baseline to end of intervention, and in Harts et al. (2008), neither of the research groups had any significant change, but with a greater improvement in the HIT group.

6.4.6 Exercise capacity

Exercise capacity was only measured by two studies (Verbrugghe et al., 2019; Verbrugghe et al., 2021). In the study by Verbrugghe et al. (2019) both of their intervention groups (HIT/LIT) made a significant improvement in VO_2max, with a significant difference in favour of the high-intensity training (HIT) group. Verbrugghe et al. (2021) had significant improvements in their HIT group but not in the moderate-intensity training group, in addition the difference between high and moderate-intensity training, was significant in favour of the HIT group.

7 Discussion

The results from this literature review show that physical exercise is beneficial for patients with chronic low back pain. A number of interesting points arose from the studies analysed. Across all five studies, no participants got worse during the exercise interventions. This suggests that physical exercise or physical activity in any form is beneficial in treating chronic low back pain.

Disability was the only category of outcome measure utilised across all five studies in this review. This is an important outcome measure within a patient-centred care approach and therefore clinically highly relevant. This indicates that the improvement of disability might be the most important aspect for patients with chronic low back pain. Regaining self-efficacy and function may be of greatest importance for patients recovering from chronic low back pain and something that must be considered at the heart of patient centred care by osteopaths. Research shows that when self-efficacy and confidence to perform daily activities is improved, disability is improved (Cohen and Rainville, 2002). In two out of five studies, (Harts et al., 2008; Helmhout et al., 2004) the Roland Disability Questionnaire (RDQ) was used to measure the decrease of disability. In four out of five studies (Helmhout et al., 2004; Iversen et al., 2018; Verbrugghe et al., 2019; Verbrugghe et al., 2021) either the Oswestry Disability Questionnaire or a variant of it was used, thus making the comparative results less reliable than if the studies would have used the same measurement tool in order to draw any conclusions of their outcome results. Although the questionnaires take interest in similar symptoms and findings, they are different, therefore making a comparative conclusion problematic. However, all intervention groups demonstrated significant/non-significant improvements following exercise intervention.

Three studies (Iversen et al., 2018; Verbrugghe et al., 2019; Verbrugghe et al., 2021) found both high-intensity training and medium intensity exercise showing a significant improvement in disability. However, two studies (Verbrugghe et al., 2019; Verbrugghe et al., 2021) demonstrate a significantly greater improvement following high intensity exercise compared to medium intensity exercise. Therefore, it is not clear if high intensity exercise provides any extra benefit over medium intensity exercise. Of note, both of the studies showing preference for high intensity exercise utilised high-intensity interval training (HIIT) as an intervention, it remains difficult to say if HIIT is advantageous compared to high-intensity training. However, exercise generally as a therapeutic modality has the primary goal of improving functioning in patients (Cohen and Rainville, 2002). Out of six intervention groups, only the HIT group in Verbrugghe et al. (2021) study experienced a slight setback between end of intervention and follow up.
Based on these results, it might be more beneficial to choose a high intensity exercise approach towards exercise over moderate intensity exercise in patients with chronic low back pain. Nonetheless, the variable findings across the small number of studies reviewed and relatively low participant numbers make it difficult to draw robust conclusions about this.

Moderate-intensity exercise appeared to be more beneficial in decreasing pain in patients with chronic low back pain compared to high-intensity exercise (Iversen et al., 2018; Verbrugghe et al., 2021). A plausible reason for this could be that the stress the body is put under during a high-intensity training session might be too much for some patients, causing a greater dissonance towards the patient's body and therefore also their pain. Pushing the body through an intense workout might reinforce their negative perception of their bodies, while moderate/low-intensity training may help recreate trust and self-love towards their bodies. Reports support that exercise on a moderate level more often leads to a positive mood and an increased feeling of pleasure, whereas exercise forms characterised by higher intensity could lead to discomfort, although these feelings will ease off with time. It might therefore be easier to encourage patients to moderate exercise than higher levels of intensity (Biddle, 2016). None of the studies applied a preparation phase with pain neuroscience for the subjects, something that is highly recommended before any exercise treatment in the management of patients with chronic pain (Nijs et al., 2015). The only study that measured pain and had a follow up measurement was Verbrugghe et al. (2021) showing that both intervention groups (HIT/MIT) improved after the end of intervention but with a greater improvement with high-intensity exercise.

The results provided by the studies that measured fear of movement and (re)injury by either Tampa Scale of Kinesiophobia (TSK) (Harts et al., 2008; Helmhout et al., 2004) or Fear-Avoidance Beliefs Questionnaire (FABQ A) (Iversen et al., 2018) possibly indicate that any kind of movement and physical exercise will lead to less fear in relation to physical activity. The question is why this did not apply to FABQ B in Iversen et al. (2018) research, measuring the fear-avoidance beliefs in relationship to work. There is possibly a bigger feeling of trust in the movements and exercises used during the treatment as they were given to the patients from professionals, creating a feeling of safety in regards to moving their bodies and possibly the graded exposure of exercise under supervision. Research supports that graded exposure and graded exercise equally improve treatment outcomes in patients with chronic low back pain. Data suggest that graded exercise exposure might be adequate to generate positive outcomes in pain intensity and disability (George et al., 2010). Two of the studies, (Helmhout et al., 2004; Iversen et al., 2018) measuring kinesophobia using two different questionnaires, both show a greater improvement with low-intensity training compared to the high-intensity training. This correlates to the outcomes between end of intervention and follow up, where all intervention groups in Harts et al. (2008) and Verbrugghe et al (2021) improved, but with greater results with low-intensity training. This illustrates that a slower paced training regime possibly creates greater improvement in kinesophobia and fear-avoidance behaviours than higher-intensity training. Although, with only three studies out of five measuring kinesophobia and fear-avoidance behaviours, in addition also applying different measurement tools, drawing any solid conclusions is difficult. Nevertheless there seems to be an indication or trend in favour of low/moderate intensity training.

Additionally, the moderate-intensity training (MIT) group in Iversen et al. (2018) study had a home-based protocol created based on their interests and preferences in collaboration with the recommendations of a physiotherapist, possibly generating a higher compliance towards the training protocol for the subjects divided into the MIT group. Unlike the MIT group, the high-intensity training group received a generalised elastic band program to perform at home, not specifically designed, or taking in regard to the participant's likes, interests and preferences.

Functional scores showed significant improvement following both high and moderate-intensity exercise (Iversen et al., 2018; Verbrugghe et al., 2019; Verbrugghe et al., 2021). However, in Verbrugge et al. (2021), the high-intensity exercise group showed a significantly better response between end of intervention and follow-up compared to moderate-intensity exercise.

Harts et al. (2008) measured a significant change in SF-36 between the high-intensity training and waiting list control group between baseline and end of intervention, with a greater improvement following high-intensity exercise. After the end of intervention the results evened out and showed no difference at follow-up 16 weeks later. Comparing the improvements between end of intervention and follow up in Harts et al. (2008) and Helmhout et al. (2004) studies, low-intensity exercise had greater improvements than high-intensity exercise.

General patient experience (GPE) in Harts et al. (2008) study showed a significant improvement in favour of high-intensity training (HIT) after intervention. This improvement eventually got overrun by low-intensity training (LIT) that kept on improving significantly after intervention. Helmhout et al. (2004) had a similar result in the GPE outcome measure, where both high and low intensity training improved between end of intervention and 6 months follow up, but with a greater improvement with HIT. Most of the results for the self-perceived health related outcomes show a similar trend, with a greater improvement with HIT. This could possibly indicate that the HIT group perceived their training effects quicker than the LIT group and therefore the leap of the HIT group in the health survey is greater in the beginning, but with time the LIT group caught up to the same level of perceived fitness.

The effect of physical exercise on anxiety and depressive symptoms was only measured by one study (Iversen et al., 2018). The significant improvement in both intervention groups is notable as this might relate to contemporary attitudes around the use of physical exercise to treat anxiety and depressive symptoms. Studies show that a regular comprehensive exercise program has positive benefits for better emotional and mental health, especially in improving feelings of anxiety and depression (De Mello et al., 2013). Even though the majority of the outcome measures calculating quality of life had equivalent amounts of improvements in the respective groups, the most significant changes and differences occurred with low-intensity training.

The only outcome measure that showed an improvement throughout all studies in the high-intensity training (HIT) groups compared to low/moderate exercise was the increase of strength. Four out of five studies that measured after intervention, showed a significant increase (Helmhout et al., 2004; Iversen et al., 2018; Verbrugghe et al., 2019; Verbrugghe et al., 2021) of strength with HIT compared to moderate-intensity training and general physical exercise. The most significant improvement was made in the Iversen et al. (2018) study where high-intensity exercise had a strong significant improvement at the end of intervention. HIT generally demonstrated stronger improvements measured after intervention until follow up.

Research suggests that it might not be the focus and actual improvement of strength and endurance that is the only working mechanism behind improving chronic pain, but that the effect on self-efficiency and central nervous system adaptation play a role as well as the musculoskeletal factors (Belavy et al., 2021). The increase in strength by high-intensity training (HIT) therefore might be beneficial in several areas when treating chronic low back pain. There are a few things that stand out in the two studies from Vergrugghe et al. (2019, 2021) compared to the others, when it comes to the measurement of strength. One is the use of intervals in their training plan, two, the incorporation of cardiovascular training. This makes them the only two studies focusing on a wider aspect of training other than the focus on strength gain alone. Could it be that this specific training method, where both strength and cardiovascular training are performed at a high-intensity and in intervals, is more beneficial? In common with the five studies, is that the increase of strength is greater for the participants having an intervention with high-intensity exercise. Based upon this result it is confident to say that exposing the body for higher resistance and force will create greater strength with a quicker increase than moderate/low intensity training or general physical exercise.

Exercise capacity only was measured by two studies, (Verbrugghe et al., 2019; Verbrugghe et al., 2021) Both of the studies by Verbrugghe et al. (2019;2021) used very similar intervention programs. With that mentioned, the results of the outcome measures show a clear tendency towards the benefits of applying high-intensity exercise to increase the VO_2max in individuals. Feeling the improvement of physique and vigour correlates with research that shows that physically active people tend to have a higher health-related quality of life measurement than physically inactive individuals. Exercise capacity is a lifestyle component and therefore holds the potential to increase quality of life in people (Schaller et al., 2015).

The number of participants in two studies was particularly low (Verbrugghe et al., 2019; Verbrugghe et al., 2021). These studies only randomised 38 people into two intervention groups and therefore dramatically undermined the strength of the results presented by these studies. None of the studies included were able to enrol more than 100 participants in their studies. This may be due to time or funding issues, or difficulty enrolling suitable participants. This reduces the strength of clear conclusions that can be drawn from these studies. Two of the studies (Harts et al., 2008; Helmhout et al., 2004) recruited their participants at the Royal Netherlands Army and only allowed male participants to partake in their research. This raises the question of how applicable the results from these studies will be for the general population, as they only undertook the research on male military. Not only is there the issue of only one sex being representated, but also the type of working environment the participants are located at. As women are more likely to develop several chronic pain disorders, chronic low back pain included, (Chenot et al., 2008) making research only studying male subjects very controversial.

The wide variety of training protocols used in the research articles is worth noting. This creates another obstacle in the comparison between the studies and the possibility of drawing a conclusion. As high-intensity training (HIT) and high-intensity interval training (HIIT) can be applied to a wide range of different exercise modalities, with a broad variation of training programs, this establishes the ability to study any exercise methodology applicable to HIT and HIIT.

The benefit of applying a follow-up measurement after the completed intervention period provides the opportunity to establish if the treatment or program was beneficial long-term, or if there is a maintained intervention effect. By choosing to only measure at baseline and after intervention, the possibility to draw any conclusions about long-lasting treatment effects is impossible. The information given will tell if the intervention was positive and helpful, but it is equally important to know if the effect of the treatment lasted, if the improvements kept on increasing or maybe if after intervention the patient's symptoms slowed and a possible setback was experienced. The general result of the studies that applied a follow-up measurement after intervention, (Harts et al., 2008; Helmhout et al., 2004; Verbrugghe et al., 2021) is that high-intensity exercise kept on improving in the majority of outcome measures, even if not all of the improvements were significant. Three outcome measures, disability, strength and exercise capacity, in the study by Verbrugghe et al. (2021) showed a tendency towards a slight setback, although continuing to be higher than the measurement at baseline. Even if these results experienced a setback, they were still of greater improvement than the results of moderate-intensity exercise. With strength and exercise capacity this could depend on the nature of physical fitness and the saying “if you do not use it, you lose it”, meaning that if you discontinue an activity or ability, you might lose it or experience a setback. Physical exercise has the ability to improve skills and competence, body image and physical fitness (PE), all leading to global changes and improvements in self-esteem. Discontinuing PE might therefore lead to a setback in those accomplished changes (Biddle, 2016). The control groups showed the same general tendency towards improvement after intervention, once again pointing into the direction that any movement and physical activity is beneficial. Meaning that the most effective exercise form as a treatment modality for chronic non-specific low back pain is still unknown (Gordon and Bloxham, 2016).

The multifactorial nature of chronic low back pain seems most logically to be treated by a broad multimodal approach, where many different interventions with both somatic and psychological elements are included (Müller-Schwefe et al., 2017). These should be, in conformity, with the patient's wishes, preferences, goals and resources to create a person-centred care for the management of their pain and situation (Ekman et al., 2011). This requires that osteopaths will need a broad knowledge of various methodologies, or closely work together with other professionals. Unfortunately, as osteopathy is not legitimated in Sweden, the possibility of being included into the primary care setting and therefore the ability to work closely together with other health care professionals is limited. Osteopaths not only have to have comprehensive knowledge about somatic dysfunctions and the relationship between musculoskeletal problems and physiology, but should also have knowledge of neurophysiology and neuronal plasticity. As anxiety, depressive symptoms and changes in behaviour are common in patients with chronic pain, feasible insight and knowledge into these aspects is preferred. These aspects of knowledge will of course be completely individual and affected by the individual interest of the osteopath, but in order to offer comprehensive care for patients with chronic pain, a higher level of expertise in these modalities will be beneficial.

Osteopaths have an important place in promoting behavioural change to obtain healthier lifestyles and better self-management in long term conditions such as chronic pain in individuals globally. Non-physician healthcare practitioners such as osteopaths can help provide additional and integrated self-management and psychological support for patients suffering from chronic musculoskeletal pain. At the University College of Osteopathy, The Osteopathy, Mindfulness and Acceptance Programme (OsteoMAP) was designed. This is an innovative care package that combines the manual therapy techniques used in osteopathy and Acceptance and Commitment Therapy (ACT). This program was constituted to maximise the potential therapeutic benefits of combining both physical and psychological interventions. As mindfulness approaches are increasingly incorporated to the psychological management of chronic pain disorders, developing this program stands immensely high in the present time. Being able as an osteopath to combine these therapies may hold a possibility for greater improvements for patients with chronic pain (Carnes et al., 2017).

Even though physical exercise is not traditionally a large part of osteopathic practice, and was not included in the original principles of osteopathy given by A. T. Still, there is some acknowledgement that exercise, diet and other modalities optimise self-regulation and self-healing mechanisms (Seffinger et al., 2011). The importance of exercise and activity for health and the lack of exercise as undoubtedly a contributor for poor health is not questioned. Many osteopaths use specific or general exercise advice as part of their osteopathic treatment.

The huge advantage of being able to implement physical activity and exercise into a multimodal treatment of chronic low back (CLBP) in patients is that it may enhance the effects of manual techniques alone. The guidelines of the CLBP management do not specify what exercise modality should be used, rather that the patient should stay or become physically active at all. Frequent movement is seen as preferable to a sedentary lifestyle (Ambrose and Golightly, 2015). This creates the ability to tailor an exercise program to the needs, preferences and resources of the patient, creating the building blocks of patient-centred care (Ekman et al., 2011).

The aetiology of chronic low back pain (CLBP) is multifactorial and therefore it is important to consider an osteopathic approach that complements this and includes aspects of a biopsychosocial model (Engel, 1977), away from a purely biomechanical approach. Even though the concepts of musculoskeletal disorders have the conceptual basis of somatic dysfunction, CLBP is strongly associated with complex human behaviour and influenced by a wide variety of different factors. Research in the field of osteopathy is currently investigating the importance of the interaction between practitioner and patient, affective and intentional touch and interoception (Esteves et al., 2020).

Touch and mindfulness-based therapies and interventions combined with manual therapy such as osteopathy may have beneficial effects on conditions associated with central sensitisation and interoceptive deficits (Casals-Gutiérrez and Abbey, 2016). Although this only affects a subgroup of individuals that suffer from chronic low back pain, (Bid, Soni and Rathod, 2011) some patients show indications of central sensitisation and having the skills to address this is very valuable. Deficits of interoception present in a range of physical and psychological health problems, including anxiety, depression, somatic symptom disorder and chronic pain. Research suggests that an effective and gentle touch in a therapeutic setting potentially has the effect to modify sensitisation states in patients (Casals-Gutiérrez and Abbey, 2016).

The complexity of treating chronic pain and chronic low back pain requires broad knowledge and engagement of the osteopath. Singular and isolated treatment methods will not be able to help the patient manage their pain long-term and therefore a biopsychosocial model with multidisciplinary approaches focusing on person-centred care incorporating physical, psychological and educational interventions should be used as these treatment approaches seem more effective in managing chronic low back pain (Casals-Gutiérrez and Abbey, 2016).

7.1 Further research

Further research on the field of high-intensity training as a treatment modality for osteopathic management of chronic low back pain is necessary. Further research could aim for larger participant numbers which would increase the power of the study and allow for more robust conclusions. Being able to recruit an equal spread across sexes will be beneficial in transferring the results by future studies to the general population.

Studying the effects of high-intensity training in combination with manual therapy and comparative results of low or moderate-intensity combination with manual therapy, only manual therapy and no treatment would be an essential addition to the research field. This would perchance provide meaningful results for the application of physical exercise in an osteopathic management of chronic low back pain.

Comparing different high-intensity training programs and exercises could maybe give an indication of which approach of high-intensity exercise is the most beneficial for patients that suffer from chronic low back pain.

These areas of potential future research may establish an improved understanding of beneficial osteopathic treatment approaches in patients with chronic low back pain.

8 Limitations

The original research question was if high-intensity interval training could be used as a treatment method for patients suffering from chronic low back pain. Difficulties were encountered finding sufficient research specifically on high-intensity interval training, so the research question was broadened to include high-intensity training generally (interval and non-interval). Only five studies met the inclusion criteria and were analysed, which is a relatively small amount. Combined with the variability in design, outcome measures and results, it is hard to draw robust conclusions.

The studies made by Harts et al. (2008) and Helmhout et al. (2004) only recruited male army employees, creating a potential limitation in the application of the results by these studies into the general population. Firstly the participants were only male, although back and spine impairments are more common in women than men, (Andersson, 1999) women generally are more severely affected by low back pain (Chenot et al., 2008). Secondly they were all active army employees, also distinguishing them from the general population, as their workfield and the requirements on their physical form will be greater than on the average population.

The completeness and clarity of the results reported varied widely across the five studies reviewed. One study did not make clear whether some results were significant or not, both in relationship between the two intervention groups but also within the groups (Harts et al. 2008). This reduced the reliability of results taken from this study. This was contradictory and not reflected in the high PEDro scale score this study attained. Helmhout et al. (2004) presented clear results but only stated the significant differences between the groups, and not within the groups. The unclear way of presenting the results in two of the five studies creates a limitation when analysing results.

Paywalls limited the inclusion of more studies. One article could not be included because of this but appeared to have met the criteria.

The search strings utilised may not have captured all of the relevant material that could be used as part of this review. There could still potentially be valid studies on the databases used that would have met the criteria to be included in this project, but were missed in the method utilised here. In addition to that, only two databases, PubMed and Cinahl, were used to cover the literature research, reducing the probability to have covered a wider range of articles accessible on various databases.

9 Ethics

All studies except for one had their research approved by a medical and health ethics committee. Helmhout et al. (2004) do not in a clear way present that their research is approved by an ethical medical and health committee, but they state that they required written informed consent from all study subjects upon the start of the research.

10 Conclusion

The results from this literature review show that high-intensity training is beneficial for patients suffering from chronic low back pain, across a variety of outcome measures such as strength, exercise capacity, disability, pain, fear of movement and quality of life. However, the effect is no better than moderate or low intensity exercise. This is in line with existing research. Physical activity and exercise of any intensity should therefore be implemented and encouraged by osteopaths for patients with chronic low back pain as part of an individualised, patient-centred care approach.

Further research on the topic of high-intensity training is required to find a more specific and beneficial approach to this exercise form specifically adjusted to the management of chronic low back pain.

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