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ROLE OF TACTILE ACUITY WITH CHRONIC NON-SPECIFIC LOW BACK PAIN PATIENTS

Effects of Graphesthesia on Two Point Discrimination

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Chronic Non-Specific Low Back Pain (CNSLBP) is a very common health problem worldwide and a major cause of disability. The causes of the onset of low back pain remain unclear and in most cases the origins remain unknown.

There is growing evidence supporting the idea that disruption of cortical structure and altered sensory function, particularly sensory acuity, is a feature of CNSLBP. These changes could contribute to the persistence of the pain state and may represent a valid focus for therapy. New treatment approaches have been introduced that aim to normalize disturbed cortical representations and improve body perception. One of these approaches is Graphesthesia tactile acuity training, which aims to stimulate the somatosensory system and reorganize the altered cortical representations of the body.

The aim of this thesis was to determine whether CNSLBP patients demonstrate disturbed tactile acuity and body perception as well as investigate whether Graphesthesia training influences their Two Point Discrimination outcomes. A literature review was made to declare the status of research and an experiment was conducted to test a Graphesthesia home training program on CNSLBP patients.

The results support earlier findings indicating that CNSLBP patients demonstrate disturbed body perception and tactile acuity of the low back. Graphesthesia training was found to improve the Two Point Discrimination outcomes, however it is still unclear whether Graphesthesia contributes to the management of CNSLBP.

This thesis was done in collaboration between Zürich University of Applied Sciences (ZHAW) and the Satakunta University of Applied Sciences (SAMK).

CONTENTS

1 INTRODUCTION

The world health organization (WHO) states chronic low back pain (LBP) as one of the most frequent reasons for medical consultations and the leading cause of activity limitation throughout the world. (WHO, 2013) Ninety percent of all low back pain is non-specific. (Kriesmer, Van Tulder, 2007) Chronic non-specific low back pain (CNSLBP) is one of the biggest reasons for inability to work and persistent disability which causes huge financial costs to countries social security institutions. (WHO, 2013)

In Finland there were over 2,1 million sickness allowance days due to LBP which cost 119,8 million euros in the year 2012. All the costs caused by early retirements were 346,6 million euros. (Käypä hoito, 2016) Total costs of LBP in Switzerland are estimated annually at 7.4 billion Euros (Wieser et al. 2014). As CNSLBP is a very common and costly health problem not only in Europe, but worldwide, newer and cost-effective treatment approaches are needed and frequently desired.

The structural or functional impairments in the spine have often been the primary focus of many therapies. This may be a factor contributing to the lack of success of current treatment approaches when it comes to the management of CNSLBP. There is growing evidence suggesting that the structural problems in the back might be insignificant. (Wand, O'Connel, Di Pietro, Bulsara, 2011)

During the past 10 years researchers have been able to study the complexity of the impact chronic pain has on the brain. Deeper understanding of cortical activity has resulted in the development of new methodologies which are currently researched in order to find new evidence based treatment approaches for CNSLBP. One such treatment approach is Graphesthesia, which focuses on the patients ability to identify letters or numbers written on the skin by purely the sensation of touch. The repeated stimulation of the skin is a form of sensory retraining that aims to effect on a cortical level. (Luomajoki, 2011)

In this thesis Graphesthesia training in relation to CNSLBP and tactile acuity is studied through a literature review and an experiment.

2 PAIN

The International Association for the Study of Pain (IASP) defines pain as an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage. In 1994, pain was acknowledged as very effective and essential, as it protects and alerts when in danger. (IASP, 2016)

Pain is typically classified as either acute or chronic pain. Acute pain can be regarded as the body's normal response to tissue damage, such as a cut, infection or a physical injury. It is a symptom that has an identifiable pathology and biological function and can usually be relieved through proper treatment. (Koestler, Myers, 2002) Chronic pain is long lasting, the pathology is often unidentifiable and is a response to unknown peripheral or central changes in the somatosensory cortex. Chronic pain does not serve a protective function and can be difficult to treat because the cause can rarely be identified. (Ojala, 2015)

In healthy individuals, peripheral receptors respond at certain tresholds of stimulation. When a stimulus triggers a response, action potentials travel along peripheral neurons into the spinal cord. The neurons release neurotransmitters and activate secondary neurons. Action potentials transmit up the spinal cord to the cerebral cortex, which is responsible for the perception of sensations. The brain evaluates this information to and makes the decision whether it is necessary to activate the alarm system or not. Previous experiences, emotional processes and consequences of a response have an influence on the evaluation of danger. (Lester, Moseley, Carus, 2013) This is why tissue damage triggers an distinctive pain response depending on the situation and previous experiences of the individual. This mechanism is what allows the ability to develop quicker reactions and increase injury avoidance. Without pain, human survival would be impossible. (Butler, Moseley, 2003).

In their book ’Explain Pain’ Butler and Moseley (2003, p. 8) mention:
"We belive that even if problems do exist in your muscles, joints, ligaments, nerves, immune system or anywhere else, it won’t hurt if your brain thinks you are not in danger. In exactly that way, even if no problems exist in your body tissues, it will still hurt if your brain thinks you are in danger."

Pain can be subcategorized into different types based on the physiopathological mechanisms. These different types include of nociceptive, neuropathic and central pain. Nociceptive pain arises from actual or threatened damage, not effecting neural tissue. Nociceptors are high-threshold sensory receptors of the peripheral nervous system (PNS) and react to nociceptive stimuli. (IASP, 2016) Nociceptive stimuli can be chemical, thermal or physical and triggers the action potential to travel-through tractus spinothalamicus lateralis to the sensori cortex, where the information is then processed. (Trepel, 2015) A disease or a lesion of the somatosensory nervous system itself causes neuropathic pain. The damage to the neural tissue can be located in the central nervous system (CNS), which includes the brain as well as the spinal cord, or it can be located in the PNS, which includes all the nerves leaving the spinal cord. (IASP, 2016) Finally, central pain is located in the CNS. In comparison to the neuropathic pain, no tissue damage is evident in central pain, but the processing of information is impaired. The central tissue shows increased sensitivity to their normal or subthreshold afferent input. (IASP, 2016) The International Association for the Study of Pain (2016) explain, “This may include increased responsiveness due to dysfunction of endogenous pain control systems. Peripheral neurons are functioning normally; changes in function occur in central neurons only.”

2.1 Chronic Pain

Chronic pain is defined as pain that lasts beyond the length of time necessary for bodily insult or injury to heal (IASP, 2016). Even though there is no definitive length of time or level of pain that can be relied upon for diagnosis, generally pain is to last at least three months before being considered chronic pain. (Saab, 2014) Butler and Moseley (2003) use Figure 1 to clarify the process of developing prolonged pain.

When pain persist and changes into chronic pain it is because brain has concluded that there is danger and it needs to be protected. (Butler, Moseley, 2013) Chronic pain is real pain, but it no longer is an accurate indication of the state of the body. (Moseley, 2012)

Figure 1 Graph of pain associated with the nervous system (Butler, 2003)

Chronic pain is a complex phenomenon that is linked very often with tiredness, sleeplessness, stress, as well as lack of motivation. Chronic pain effects many aspects including certain movement patterns and often results in loss of flexibility and strength. There can be a variety of different reasons behind the development of chronic pain. Some of these reasons can be tissue damage, active disease processes or other insults to the body. Different conditions can also lead to chronic pain, like for example, cancer, rheumatoid arthritis, cardiac diseases and musculoskeletal problems. (Koestler, Myers, 2002)

Some studies have investigated the causes and complexity behind the persistence of pain. Furthermore, they have explored how particularly age, gender, stress and fears influence the risk of developing chronic pain. (Costigan, Scholz, Woolf, 2009) Cognitive factors play an important role in the development of the chronic pain and should be taken into consideration when treating a chronic pain patient. These are the conscious thoughts that the person has about their condition. Developing hypervigilance and kinesiophobia, the fear of movement due to pain, is common. Negative thinking like fear and catastrophizing can be an obstacle for recovery and rehabilitation and it can aggravate illness behavior. (Waddell, 2004) These factors may lead to disability

and despair over time. (IASP, 2016). People with pain can have mistaken beliefs about their condition and therefore pain education is important when treating a chronic pain patient (Waddell, 2004).

2.2 Cortical changes

The central nervous system (CNS) has the capability to adapt throughout life. This ability to adapt or reorganize according to the functional demands is called brain plasticity. These changes in the brain are a part of normal development and learning. (Moseley, Flor, 2012) Newest technologies in the brain scan have given researchers more insight and confirmed the numerous structural and functional changes within the brains of people with chronic pain. These changes affect the brain so that it is being informed wrongly about the level of danger in the peripheral tissues. Persistent pain may lead to changes in the spinal cord, and consequently changes in the brain. (Butler, Moseley, 2003)

The latest findings have shown that there is not only one center of pain, but many. Although multiple areas in the brain activate during the pain experience, there are a few cortical areas that that are involved more frequently than others. The primary somatosensory cortex is one of these areas that activate in relation to a pain experience. (Moseley, 2008b)

Within the brain there are several virtual body representations to be found. A virtual body representation is refferred to as the cortical homunculus (lat. 'little man'). The homunculus that is devoted to sensation, is located on the somatosensory cortex on the postcentral gyrus of the anterior parietal lobe. (Trepel, 2015) Bodily representations of the primary somatosensory cortex are constantly modified according to sensory input. Increased input due to training as well as loss of input due to deafferentation are reflected as changes in the cortical homunculus. (Flor, 2003)

As the brain gets a flood of information about the body part in which pain is experienced, it generates a larger representation in the virtual bodies on the homunculus.

Areas which are normally devoted to specific body parts start to overlap and the representations get blurred. Butler and Moseley call this "smudging of the virtual bodies". They use following image for clarification of this process (Figure 2). (Butler et al. 2003)

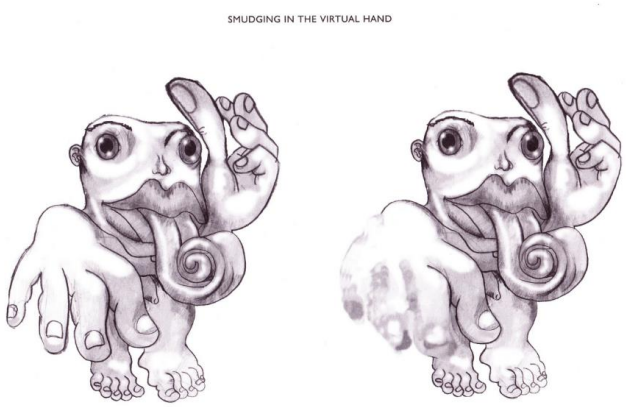

Figure 2 Smudging in the virtual hand (Butler, 2003)

This disruption of the cortical representations and its impact on body perception, as well as on tactile acuity, will be explained later on (Butler et al. 2003).

When pain becomes persistent neurons in the spinal cord become more sensitive and more efficient at sending danger messages from the tissues to the brain. When the virtual representation of the affected body part in the brain is enlarged, the brain pays more attention to the affected area. The smudging of the virtual bodies can result in overlapping of the brain areas devoted to certain areas of the body which can result in the sensation that the pain is difficult to point out or that it is spreading to adjacent body parts. These changes in addition to negative thoughts and catastrophizing result in central sensitization. This means that the CNS becomes oversensitive, the brain receives magnified danger messages from the spinal cord and pain persists. (Moseley, 2012)

There is growing opinion that these cortical changes contribute to the development and maintenance of the chronic pain state. (Wand et al. 2010). Studies concerning this subject have encouraging results suggesting that following the right treatment however, brain plasticity allows for these abnormalities in cortical reorganization as well as their symptoms to resolve. (Luomajoki, 2011)

3 CHRONIC NON-SPECIFIC LOW BACK PAIN

Krismer et al. (2007) define low back pain (LBP) as pain localised between the 12th rib and the inferior gluteal folds. LBP is usually categorized into three subtypes. This subdivision is based on the duration of the back pain. These three types are acute, sub-acute and chronic low back pain. (Duthey, 2013) Acute low back pain is of short duration that lasts for less than 6 weeks. Sub-acute low back pain lasts 6-12 weeks and chronic low back pain lasts for 12 weeks or more. (Käypä hoito, 2016)

Chronic low back pain (CLBP) can be classified into specific and non- specific chronic low back pain. Majority of the cases are non-specific, as only in about 10% of cases the specific origin for CLBP is identified. (Krismer et al. 2007) Chronic non specific low back pain (CNSLBP) is divided into two sub groups. Pain with non-mechnical and mechanical nature. Non-mechanical CNSLBP is not as common and is often linked with central sensitivity. Mechanical CNSLBP is more evident and is linked closely to a mechanical problem which either is caused by lack of motor control or hypomobilty of the spine which persists the pain. (O'Sullivan, 2005)

Chronic pain is a multidimensional illness which requires a multidisciplinary approach to understand the phenomenon of it. Accordingly, a multidisciplinary rehabilitation program is required to manage it. (Ojala, 2015) According to evidence based treatment guidelines there are some intervention strategies that have proven to be effective and are recommended in the management of CNSLBP. Therapeutic exercise which focuses on training motor control and stabilization of the back muscles has been proved to reduce pain and enhance returning of functional capacity. In addition to this, cognitive behavioral therapy and thorough patient education is recommended to relieve psycho-physical symptoms. Also, pharmacological treatment and manual therapy have proven useful. (Käypä hoito, 2016)

4 BODY PERCEPTION AND CNSLBP

It has been argued that the cortical changes and the disrupted cortical repsentations of the body following chronic pain result in the disturbance of body perception (Wand et al. 2011). CNSLBP patients often exhibit deficits in proprioception and struggle performing tasks that require the sense of body awareness, for example tasks that require the subjects to sense control the movement and direction (Luomajoki, 2015). Patients with CNSLBP have been found to demonstrate disturbances in tactile acuity, problems with identifying letters that are traced on the back and find it difficult to mark the outline of their back when asked to complete a drawing on their pain sensation (Moseley, 2008a). In some cases CNSLBP patients report that they no longer feel as their back being a part of them and feel as they are not able to control their back automatically and effortlessly (Tracey, Bushnell, 2009).

A variety of questionnaires, movement control and sensory tests have been developed and are used to assess whether CNSLBP patients show signs of disturbed body perception (Luomajoki, 2015).

4.1 Tactile Acuity

Chronic pain is often associated with reduced tactile acuity. Tactile acuity refers to the extent to which one can recognize small stimulus applied on the skin. It has been studied that a relationship exists between pain intensity, tactile acuity and the cortical representations. When pain resolves, tactile function improves and cortical organization normalizes. (Moseley, Zalucki, Wiech, 2008)

Two Point Discrimination (TPD) is one method that can be used as a measurement tool when evaluating the tactile acuity of a specific body part. The test measures the patients ability to differentiate between two light stimuli that are applied to the skin simultaneously. (Mørch, Andersen, Quevedo, Arendt-Nielsen, Coghill, 2010) Areas with low TPD thresholds, such as the nose and hands, are represented by large areas on the homunculus while areas with high TPD thresholds, such as the back and legs,

are represented by small areas on the homunculus. This leads to the distorted representation of the body by the homunculus. (Luomajoki, 2015)

The representations may change when signals from a specific body part are prevented from reaching the cortex. In contrast, the representation can also change in relation to an increase in stimulation. For example, musicians who play stringed instruments have larger cortical representations on their highly stimulated finger tips and therefore have very low TPD thresholds in those areas. (Kolb, Whishaw, 2001)

TPD testing can be used as a form of assessing tactile acuity to find out whether chronic pain has altered the cortical representations on the painful body part (Mørch et al. 2010). Increased TPD thresholds may indicate of sensory loss and cortical alterations (Luomajoki, 2015).

4.2 Graphesthesia

New treatment approaches that explicitly target brain function have already been studied and tested in other chronic pain problems such as complex regional pain syndrome and phantom limb pain which are also characterized by significant cortical dysfunction. (Wand et al. 2011)

Graphesthesia is one treatment approach that is used for cortical sensory retraining to improve tactile acuity. (Luomajoki, Moseley, 2009) It focuses on the patients ability to identify letters or numbers written on the skin by purely the sensation of touch. The aim of Graphesthesia is to stimulate the somatosensory system and reorganize the altered cortical representations of the body. (Gutknecht et al. 2014) Graphesthesia as a form of tactile acuity training has not been studied in great detail and has limited substantial evidence. Earlier studies that have combined Graphesthesia training with other treatment approaches have however presented encouraging results in the management of CNSLBP. (Luomajoki, 2015)

5 AIM OF THE THESIS

Within the past ten years researchers have been studying the relation of chronic pain, brain tissue modulations and body awareness. While many studies prove the brain tissue modulation with chronic pain patients, there is still a lack of evidence for treatments that stimulate tactile acuity and trigger cortical reorganisation.

The aim of this thesis was to declare the status of research on the topic of CNSLBP and Graphesthesia training. Additionally the aim was to experiment a Graphesthesia home training program on CNSLBP patients and study the effects on Two Point Discrimination. The research questions addressed in this thesis are the following: Do patients with chronic non-specific low back pain demonstrate disturbed tactile acuity and body perception? And furthermore: How does graphesthesia home training influence lumbar TPD outcomes of CNSLBP patients ?

This joint thesis aims to answer these research questions through a literature review completed by Muriel Wirth from Zürich University of Applied Sciences and through an experiment conducted by Sara Salerto from Satakunta University of Applied Sciences. Specific research questions set separately for the literature review and the experimental part are listed further on.

5.1 Research Questions approached in the Literature Review

1. What is the current status of research on the distrubance of tactile acuity and body perception with CNSLBP patients ?
2. How does Graphestheisa training effect tactile acuity ?

5.2 Research Questions approached in the Experimental Part

1. Do patients with CNSLBP demonstrate disturbances in lumbar two point discrimination and back perception?

2. Is there a connection between Two Point Discrimination detection thresholds and Fremantle Back Awareness Questionnaire scores?
3. How does a four week duration of Graphesthesia home training influence the Two Point Discrimination values of CNSLBP patients?
4. How is Graphesthesia as a form of home training for CNSLBP patients?

6 METHOD

This particular topic was chosen for it being a current and growing area of focus in the field of physiotherapy. Before the thesis process was begun existing information on the topic was reviewed to deepen knowledge and acquire a comprehensive general idea of the focus of research. The intention was to identify to what extent had the matter been studied before and what are the areas that cause for interest.

6.1 Approach

To approach the research questions, scientific books, websites and studies were used to create a deeper understanding of the theoretical background as well as determine the current status of research done on the topic. A range of English, Finnish as well as German sources were used.

Within the theoretical background the key concepts, pain, CNSLBP, tactile acuity and Graphesthesia were defined. The research questions were first approached with a systematic literature review studying the reliability and the effects of Graphesthesia on Two Point Discrimination. Furthermore, a Graphesthesia home training program was tested and studied through an experiment implemented in Finland.

6.2 Joint thesis

This joint thesis was done in collaboration between two Universities. The students were from Zürich University of Applied Scienes (ZHAW) Winterthur, Switzerland and Satakunta University of Applied Sciences (SAMK) Pori, Finland. This process differed slightly in comparison to a classic joint thesis process. Before the collaboration could start, the framework had to be settled in order to match the thesis requirements of both Universities.

This thesis was formatted in two different layouts based on the requirements of each University, however the content is almost identical. The process was supervised by two teachers, one from each University. Communication was managed through Skype, e-mail and arranged meetings.

7 LITERATURE REVIEW

The status of research was determined with a literature review. The aim of this first part was to reflect on the previous research and discover the degree of evidence on the topic of CNSLBP, tactile acuity and sensory retraining. The current hypothesis is that tactile acuity is evidentially impaired with CNSLBP patients and improves with Graphesthesia training.

The specific research questions to investigate within the literature review part are as follows:

1. What is the current status of research on the distrubance of tactile acuity and body perception with CNSLBP patients ?
2. How does Graphestheisa training effect tactile acuity ?

7.1 Keywords and Databases

For the literature research the databases CINAHL, Medline and PubMed were used. The decision on these databases was based on the description of each database. The keywords "Chronic non specific low back pain" or "chronic pain", "graphesthesia", "two point discrimination", "tactile acuity" or "sensory (re)training" or "sensory acuity" or "body image" and "physio*". The Boolean operator "AND" and "OR" were combined for a multi-field search.

7.2 Inclusion and Exclusion criteria

Setting inclusion and exclusion criteria for the literature review help in the process of including the most current and relevant studies. The inclusion and exclusion criteria set for this literature review are listed below.

Inclusion

- Non Specific Low Back Pain
- Chronic Symptoms (> 12 weeks)

- Assessment: Two Point Discrimination
- Intervention: Graphesthesia training

Exclusion

- Year of publication (published within past 10 years)

7.3 Selection of studies

With the assistance of a keyword-based search, 29 potential studies were found. Out of those potential studies, ten studies fit the criteria to be further considered for inclusion of the literature review. After applying the exclusion and inclusion criteria, five studies scored 4/5 and were chosen to be further analyzed in the light of the research question. Table 1 presents the selection process and scoring.

Table 1 Study selection process and scoring

	Burkhard et al.	**Gutknecht et al. (2014)**	**Lewis et al. (2012)**	**Luomajoki et al. (2009)**	**Morch et al. (2010)**	**Moseley et al. (2009)**	**Moseley GL. (2008)**	**Wand et al. (2011)**	**Wand et al. (2014)**	**Wand et al. (2010)**
NSLBP	NO	YES	NO	YES	NO	NO	YES	YES	NO	YES
> 12 Weeks	YES	NO	YES	YES	NO	NO	YES	YES	NO	YES
Assessment: TPD	NO	YES	YES	YES	YES	YES	YES	NO	YES	YES
Intervention: Graphesthesia	NO	YES	NO	NO	YES	NO	NO	YES	NO	NO
≤10 Years old	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Total	2	4	3	4	3	2	4	4	3	4

8 RESULTS OF THE LITERATURE REVIEW

The study selection process concluded with five studies being selected. All studies have all been published within the last 10 years and are considered relevant to be further analyzed. Table 2 has listed the names of the studies, the authors and includes a briefing on each of the study designs. Futher on, each study is summarized and analyzed in more detail.

8.1 Depiction of studies

Table 2 Studies included in the literature review

Authors	**Name**	**Year**	**Design**
Gutknecht, M., Mannig A., Waldvogel A., Wand BM., Luomajoki H.	The effect of motor control and tactile acuity training on patients with non-specific low back pain and movement control impairment	2014	Longitudinal Cohort Study
Wand BM., Di Pietro F., George P., O'Connell NE.,	Tactile thresholds are preserved yet complex sensory function is impaired over the lumbar spine of chronic non-specific low back pain patients: a preliminary investigation	2010	Cross-Sectional Case Control Study
Luomajoki, H., Moseley GL.	Tactile acuity and lumbopelvic motor control in patients with back pain and healthy controls	2009	Cross-Sectional Case Control Study
Wand BM., O'Connell NE., Di Pietro F., Bulsara M.	Managing Chronic Nonspecific Low Back Pain With a Sensorimotor Retraining Approach: Exploratory Multiple-Baseline Study of 3 Participants	2011	Longitudinal Cohort Study Single Case
Moseley GL	I can't find it! Distorted body image and tactile dysfunction in patients with chronic back pain	2008	Cross-Sectional Case Control Study

Study 1: The effect of motor control and tactile acuity training on patients with non-specific low back pain and movement control impairment - Gutknecht, M., Mannig A., Waldvogel A., Wand BM., Luomajoki H. (2014)

Aim: The first aim of this study was to determine whether CNSLBP patients with a motor control impairment demonstrated improvement in outcome with combined tactile acuity and motor control training. The second aim was to determine if tactile acuity training enhances the effect of motor control training.

Design: This study was designed in two parts. Within the first part, a multi-center cohort study was elaborated. This part did not include a control group. The results of different assessment were discussed in a longitudinal cohort study. In the second part of this paper, the results of part one were compared to an historic control group (Luomajoki, Kool, DeBruin, Airaksinen, 2010) in a meta-analysis. The study of Luomajoki et al. (2010) was similar in inclusion of participants and motor control interventions, but did not contain any tactile acuity training or measurements.

Participants: 39 participants (19 female, 20 male) which were recruited from three private physiotherapy practices within the canton of Zurich CH between May 2011 and December 2011. Participants were included if they were between 18 and 75 years of age and suffered from mechanical NSLBP of at least six weeks duration. This included local LBP and radiating pain, but without neurological findings (muscle weakness, loss of sensibility or reflexes). In addition participants were required to have a partner at home to facilitate Graphesthesia training. The exclusion criteria were serious pathologies, such as unhealed fractures, tumors, acute trauma or serious illness, contraindicated to exercise, psychological and psychiatric problems, alcoholism or drug abuse. All participants were referred to physiotherapy by their medical practitioners with a diagnosis of NSLBP and were further classified by the treating physiotherapist with a demonstration of MCI (motor control impairment) and evidence of disturbance of sensory acuity.

Measurements: Physical measurements for motor control and tactile acuity were tested before and after the intervention. The Motor Control Test Battery (MCBT) and Two Point Discrimination (TPD) were used as standardized evaluation tools. To get data about the level of disability the authors used the Roland Morris Disability Quest (RMDQ) and the Patient Specific Functional Scale (PSFS). The historic control group (Luomajoki et al. 2010) did not undertake the TPD testing.

Interventions: Participants were provided with training to improve impairments in lumbopelvic control. Each therapist could decide how best this was achieved for each individual patient and included both training within the clinic as well as home exercises (10 min per day). Training of sensory awareness was facilitated using Graphesthesia training. Within the clinic the physiotherapist wrote letters or numbers on the low back of the participant with their finger and the participants had to guess what the therapist had written on their back. The symbols were drawn in a variable manner within and between training sessions (e.g. big, small, vertical, horizontal or diagonal). Participants had on average 9 treatments by physiotherapist each session lasting approximately 30 min. Participants were instructed to practice both, Graphestesia and motor control, daily at home.

The historic control group undertook only the motor control exercises.

Results: All assessments of the longitudinal testing in Switzerland show significant improvement. The effect size for all four outcomes suggest moderate to large treatment effects. In comparison to the historic control group, those results get shattered by no significant differences from the intervention group with tactile acuity training to the historic control group without tactile acuity training.

There was no significant difference between participants in the primary study as the Intervention group and those in the historical control on most important demographic and clinical characteristics. There was no significant difference for the PSFS or MCTB. However, patients in the primary study had significantly lower RMDQ scores than those in the historical control. The mean value of the RMDQ within the intervention group is 5.8 (SD 4.2) and 8.9 (SD 5.7) of the historic control group. Within this meta-analysis, this was the only significant outcome. The effect of tactile acuity training remains questionable.

Study 2: Tactile thresholds are preserved yet complex sensory function is impaired over the lumbar spine of chronic non-specific low back pain patients: a preliminary investigation - Wand BM., Di Pietro F., George P., O'Connell NE., (2010)

Aim: The aim of this study was to establish whether patients demonstrate a deficit in Graphesthesia performance (letter error rate) as well as the relationships between Graphesthesia performance, tactile acuity and simple tactile thresholds. The authors had the hypothesis, that CNSLBP patients would show a normal tactile threshold, but

would demonstrate deficits in TPD and Graphesthesia performance. They predicted a relation between Graphesthesia performance, tactile acuity and the severity of the clinical condition.

Design: This study was constructed in a cross-sectional case-control study design with an equal amount of patients and controls. The setting was laboratory based in Perth, Australia.

Participants: The intervention group was assembled of 19 volunteers with CNSLBP from the neurosurgical waiting list of a district general hospital and a private physiotherapy clinic in Perth, Western Australia. The subjects were included in the study if they were aged between 20 and 55 years, had experienced non-specific low back pain for more than 6 months, were proficient in written and spoken English. Participants were excluded if they presented with signs and symptoms suggestive of nerve root pain, evidence of specific spinal pathology (e.g. malignancy, fracture, infection, inflammatory joint or bone disease), were pregnant or less than 6 months post-partum, had a coexisting major medical disease or had undergone previous spinal surgery. The control group was assembled of 19 healthy volunteers drawn from students and staff of the University of Notre Dame Australia. They had to be between 20 and 55 years of age, currently pain free, had not experienced any low back pain episodes sufficient to restrict work or leisure within the last 5 years, were not pregnant or less than 6 months post-partum, had no major medical disease, were proficient in written and spoken English.

Measurements: Different tests were applied to both groups. All participants rated their back pain intensity on the NRS (0-10), filled out the SF-36 survey, aswell as the HADS to estimate state of depression and anxiety. To assess sensory functions, the physiotherapists focused on tactile thresholds as well as cortical sensory functions. To detect tactile threshold, they measured the sensitivity to touch in mg. Therefore, they used Semmes-Weinstein monofilaments which were held in a 90° angle and pressed to the skin for 1,5s. The patient had to acknowledge in case of sensation. To assess cortical sensory functions TPD detection threshold and the letter error rate within Graphesthesia were tested.

Results: Statistically significant differences were found between controls and patients in cortical sensory functions, letter error rate and TPD. Inspection of the mean scores present a higher TPD detection threshold and a higher letter recognition error rate in

patients with CNSLBP patients. These results are supportive of the notion that CNSLBP is characterized by a dysfunction of processing of sensory information from the painful area. There was no significant difference between patients and controls in tactile threshold testing. The correlation between TPD and letter error rate, as well as tactile threshold were not significant. These outcomes prove tactile thresholds over the lumbar spine are preserved, suggesting that the dysfunction of processing sensory information may be located at a central nervous system level.

The study provides a graphical analysis of patients results of NRS pain scale, SF-36 and HADS compared to the results of the sensory function tests. Within the patient group there is no significant correlation between cortical sensory function and clinical functions.

Study 3: **Tactile acuity and lumbopelvic motor control in patients with back pain and healthy control -** Luomajoki, H., Moseley, GL. (2009)

Aim: The aim of this study is to determine the relationship between back pain, TPD threshold at the back and lumbopelvic control. In this study the authors hypothesized that increased TPD threshold relates to worse voluntary lumbopelvic control. Back pain patients were expected to have an increased TPD threshold at the back than healthy controls.

Design: A cross sectional case control study design was applied to answer the research question. The testing of the participants took place in a private physiotherapy practice in Switzerland.

Participants: A convenience sample of 45 patients (20 males and 25 females) with non-specific low back pain for at least 3 months was selected. Included were patients who described a pain area between the spinous processes of T10 and L5. Patients were excluded if the interview revealed red flags or the physical examination revealed non-stable neurological signs. Radiation pain in the leg was no exclusion factor. The healthy control group was assembled with 20 males in comparable age to the patient group. Not included were controls if they had back pain that impaired activities of daily life in the past 2 years or had a neurological, orthopedic or psychiatric condition that would affect lumbopelvic control or tactile acuity.

Measurements: To answer the research question of this paper, different assessment tools were used to include as many variables as possible. The RMDQ and The coping

strategies questionnaires were used as an addition to the usual interview by their physiotherapist. TPD was assessed horizontal and vertical, with plastic caliper points ruler. The measures were out of sequence, therefore randomized. To assess lumbopelvic movement control, the authors used the MCTB which contains of six tests to show whether the motor control functions of the lower back are impaired or not.

Results: No significant difference between patients and controls was found on habitual, activity, height and weight ($p>0.2$ for all variables). Overall the vertical TPD thresholds was less than horizontal TPD threshold. TPD threshold was greater in patients than in controls, especially the difference between horizontal TPD thresholds of patients and controls was significant. The MCTB showed better outcomes in healthy controls than in CNSLBP patients ($p<0.001$). As hypothesized, the higher TPD thresholds at the back were, the more MCTB tests were positive. This suggests that decreased tactile acuity contributes to poor motor control functions and has to be considered in the treatment plaining of CNSLBP patients.

Study 4: Managing Chronic Nnspecific Low Back Pain with a Sensorimotor Retraining Approach: Exploratory Multiple-Baseline Study of 3 Participants

-Wand BM, O'Connell NE, DiPietro F, Bulsara M. (2011)

Aim: The aim of this study is to outline and evaluate a program for the management of CNSLBP. This study is to describe the effects of participation in this intervention program on pain intensity, interference of pain with daily life and self-reported disability. The authors also investigated the safety of those interventions by recording any adverse reactions.

Design: An exploratory multiple-baseline cohort study with 3 participants was designed. Therefore a replicated single case study design was used and adjusted to 3 participants. It was a longitudinal study.

Participants: Patients were included if they presented with non-specific low back pain for more than 12 weeks, score more than 4 on the RMDQ, are between 18 and 60 years old and had someone at home to facilitate home training. Participants were excluded if they showed nerve root pain, evidence of specific spinal pathology, pregnancy or less than 6 month post-partum, had a coexisting major medical disease, had contraindications for general exercises or had undergone spinal surgery within the past 2 years. Detailed descriptions of each participant are presented in Tables 3, 4 and 5.

Table 3 Description of participant 1 of the Wand et al. (2011) study

Participant 1:	
Age/ Gender:	29 years old / female
Family, Social, Work:	2 children, works part time as waitress
Pain:	Bilateral low back pain, bilateral buttock pain and right side posterior leg pain → back pain is the main concern
Pain history:	Begun in 1998 after a car accident (10 year to date of study) Treatment: manipulations, acupuncture, hydrotherapy, stability retraining, yoga, multidisciplinary pain management, facet joint injections, lumbar medial branch neurotomy and surgical insertion of spacer (2000) → no effect with listed treatments Physical therapy once a month to date
Medication to date:	Oxycodone (20mg, 4 times daily), supplementary Oxycodone as a rescue medication (20mg, 2 or 3 times per week), Co-Codamol (up to 6 tablets per day) and medication for depression
Contributing factors and contraindications:	Depression (weekly psychiatric care) and an eating disorder, No 'Red Flags' were evident, no contraindications to exercise and lower-limb neural integrity appeared to be normal on screening

Table 4 Description of participant 2 of the Wand et al. (2011) study

Participant 2:	
Age/ Gender:	33 years old / male
Family, Social, work:	Works as s school conselor and research assistant
Pain:	14 month history of bilateral low back pain and left-side leg pain → back pain is the main concern
Pain history:	Begun in 2007: 1 hour after he did some heavy lifting at home. The symptoms settled down after some chiropractic manipulations over the next 3 weeks, but did not resolve fully. Since that constantly uncomfortable and wary of movement. 3 further episodes of severe disabling pain January 2008, March 2008 and August 2008 (each episode took several weeks to settle) First two explain as recurrences, the third after prolonged sitting during a long flight.
Medication to date:	No pain medications, no other medication listed
Contributing factors and contraindications:	General health is unremarkable, no 'Red Flags' were evident, no contraindications to exercise and lower limb neural integrity appeared to be normal on screening.

Table 5 Description of participant 3 of the Wand et al. (2011) study

Participant 3:	
Age/ Gender:	55 years old, female
Family, Social, work:	Nurse, currently employed in a health care administration role after working many years in a clinical setting
Pain:	Four year history of bilateral low back pain and some left side buttock pain → back pain is the main concern She reported not only constant deep background pain but also frequent sharp grabbing pain that immobilized her for about 1 minute.
Pain history:	First incident after lifting some equipment on the ward in 1994; she reported being unable to move for 3 days. She had experiences episodic back pain from that time until about 4 years ago → the pain became constant and progressively worse. During that period she had undergone several courses of physiotherapy and chiropractic manipulations → no success Recently she had undertaken a clinical Pilates program, which she believed worsened her condition. She had controlled her mild hypertension.
Medication to date:	Paracetamol (regularly for back pain)
Contributing factors and contraindications:	No 'Red Flags' were evident, no contraindications for exercise and lower limb neural integrity appeared to be normal on screening.

Measurements: The primary outcome measurements of this study were pain intensity, pain interference and self reported low back pain–related disability. Data on these parameters were collected weekly throughout the study. Pain intensity was measured with the Brief Pain Inventory. Separate scales were provided for general activity, mood, walking ability, normal work, relationships with other people, sleep, and enjoyment of life. The scores were averaged to determine a final pain interference score out of 10. Self-reported low back pain–related disability was measured with the RMDQ, in which Participants were asked to indicate whether their low back pain interfered with the performance of 24 separate activities. Scores range from 0 to 24, with higher numbers indicating greater self-reported disability. At the end of each week, participants were asked to record any adverse reactions to the treatment and the use of any co-interventions, including changes in medication.

Intervention: Each patient underwent a brief education session about CNSLBP, cortical dysfunction and disturbances in body perception as well as explanations of the treatment program. All patients got a copy of the book 'explain pain' to take home. The

physical program included 5 stages with both sensory retraining and motor retraining exercises. Each stage was planned to last a minimum of two weeks but could be extended by one week if participants did not master that stage. Formal treatment in the clinic for 1 hour per week during the first 2 stages and then twice per week for the remainder of the program (total of 16 hours). Participants were given a home exercise diary and requested to practice the training at home for 30 minutes three times each day throughout the treatment period. Participants were asked to document the completion of each home training session in their diaries.

Results: All participants showed reductions in pain intensity, pain interference, and disability during the treatment period and maintenance of these improvements during the posttreatment period. Further data suggested that participants clinical status improved with treatment. There were significant reductions in pain intensity, pain interference, and disability throughout the experimental period. The differences between the pretreatment phase to the treatment phase and between the pretreatment phase to the posttreatment phase were also significant. No participant recorded any adverse reactions to treatment and none were reported to the treating clinician. No participant reported the use of any new interventions during the treatment or follow-up period. Participant 1 discontinued her regular physical therapy care and reduced her oxycodone dose by more than half. She reported that she continued to take oxycodone because of the effects of withdrawal rather than for pain relief. Participant 2 discontinued his regular chiropractic treatment. Participant 3 reported no longer taking pain relieving medication for her back problem.

Study 5: I can't find it! Distorted body image and tactile dysfunction in patients with chronic low back pain - Moseley GL. (2008)

Aim: The aim of this study is to determine if there is disrupted body image and tactile acuity in patients with CNSLBP as it has been found in patients with complex regional pain syndrome and phantom limb pain. Due to those answers, treatment strategies used for disrupted body images could be adjusted for CNSLBP patients.

Design: A case control study with the design of a cross sectional investigation of a small group of patients with CNSLBP and a comparison group of healthy controls was used determine the hypothesis of the authors.

Participants: A sample of six patients (three females, three males) who suffered a greater than 12 - months history of classified non-specific back pain, had been referred

for physiotherapy treatment and were unable to voluntarily tilt their pelvis in the sagittal plane while standing, were selected for this study. All spoke English as a first language and had completed formal education at least to a high school level. The control group was set together out of ten patients (five females, five males). All presented for treatment of upper limb pain and had no history of back pain in the last 2 years. The age was similar to the group of patients.

Measurements: To test the accuracy of the participants body image, they had to stand in front of a waste-high bench and had to draw the posterior surface of their back. They received a line drawing which showed the top and the bottom of the trunk. Participants were given the following instruction: ‘‘Concentrate on your back. Add to this drawing by following the outline of your own back as you track it in your mind. Concentrate on where you feel your back to be. Also draw in the vertebra that you can feel. Do this without touching your back. Your drawing should relate to your own sense of your back. Don’t draw any part you can’t sense. Do not draw what you think your back looks like – draw what it feels like.” (Moseley, 2008)

On finalization of the drawing, patients rated their pain with the VAS scale. To evaluate tactile acuity, two point discrimination threshold was measured. TPD was assessed bilaterally on 16 levels from T4 to the bottom of the gluteal folds. The examiner took three measures on each side at each level. The medial point was 1 cm, 2 cm and 3 cm from the midline. The levels were randomly taken and counterbalanced until six measures (three each side) were obtained. The average of these three measures at each level was used for analysis. As a third measurement, Moseley used von Frey hair filaments to detect tactile threshold of each participant. The levels and sides were randomized. The average of an ascending series and a descending series was considered the tactile threshold.

Tactile threshold and TPD at a given level were considered to be increased if they were more than three SD greater than the average obtained across all levels for that participant. After the data collection was completed, the six patients had to go through a full clinical interview and physical examination.

Results The body image drawings, tactile threshold and TPD testings were unremarkable and consistent across levels and sides within the control participant group. The patient group showed consistent tactile threshold across the back. The values were similar to the control values. The author describes notable results in three phenomena. First, the body image drawings showed, five out of the six patients couldn’t delineate

the full extent of their trunk. No patients drew all their vertebrae. The levels of missing vertebrae coincided with the level at which the delineation of the trunk outline was lost. Without exception, this missing outline of the body image occurred at level and side of their usual location of chronic back pain. Second, in five out of six patients was the TPD rate greater at the side and level of these missing outlines. Any other level did not differ to the control data. Third, patients who did draw their vertebrae, had a tendency for the vertebrae to be displaced from the midline, toward the painful side. All CNSLBP patients demonstrated disrupted body image and decreased tactile acuity at the level and side of back pain.

8.2 Methodological characteristics

Before the results of the studies were compared, the methodological characteristics of the studies were reviewed with the STROBE Statement Checklist (APPENDIX A). The STROBE Statement Checklist was created to strengthen the reporting of observational studies in epidemiology. The checklist is applicable on cohort, case-control and cross-sectional studies. (ISPM University of Bern, 2017) The evaluations within the different sections helped to establish the deficiencies of each study.

Table 6 Overview of STROBE Statement outcomes

	Study 1 Gutknecht et al. (2014)	**Study 2 Wand et al. (2010)**	**Study 3 Luomajoki et al. (2009)**	**Study 4 Wand et al. (2011)**	**Study 5 Moseley (2008)**
Title, Abstract	2/2	2/2	2/2	2/2	1/2
Introduction	1/1	1/1	1/1	0,5/1	1/1
Objectives	1/1	1/1	1/1	0,5/1	1/1
Methods	13/14	10/14	10/13	11/14	6/12
Results	7/10	8/9	6/9	8/10	7/9
Discussion	1/4	4/4	4/4	4/4	4/4
Other Information	1/1	1/1	1/1	1/1	1/1
TOTAL	25/33 75,8%	27/32 84,4%	25/31 80,6%	27/33 81,8%	21/31 67,7%

STROBE is a checklist created to evaluate the completeness of studies and not their quality. The conclusion from completeness to their empirical quality would be very speculative. Never the less, it shows the deficiencies of each study, which can potentially influenced their quality. The interpretation of a paper relies on its completeness. Within this paper, findings were considered significant if the score on a certain part was lower than 50% complete. All studies (Table 6) reached this limit in the total outcome. Study 5 achieved the lowest score. Especially the method of Study 5 was significantly low. In Study 1, the authors only reached 25% of completeness within their discussion. However some studies scores lower than others in certain aspects, all studies were considered suitable to take into account.

8.3 Discussion

Different aspects of the selected studies will be discussed and compared in order to establish the relevance of the reviewed studies and their outcomes on our research question. These aspects include of the study designs, measurements, participants, interventions and the results.

Design: From the total of five studies that were included in this literature review, a total of three were cross sectional case-control studies (Study 2, 3 and 5). Those studies triggered a more momentarily insight on the difference outcomes of tests with CNSLBP patients, therefore only a single testing day was necessary and no interventions or longitudinal data was raised. The remaining two studies were set on a longitudinal study design. Study 1 was split in two parts, where part one was a longitudinal multi-center cohort study with a meta-analysis to an historic control group in its second part. Meta-analyses are a simple tool to cross link data to earlier studies, without having the additional work load of a control group. On the down side, often data is slightly different and more difficult to compare. The second longitudinal study was designed without a control group as well. Study 4 was created in a replicated single case study design, which they adjusted to match and compare three single case studies in one paper. The three patients were treated with the exact same treatment plan. This paper was designed as a preliminary investigation on a new treatment program. The disadvantage of this design is the small participant number and results can only be compared

to each other, what leaves the only conclusion of whether the program outcome is positive or not but no further information on the reasoning of the effects.

Measurements: All of the studies, except Study 4, used TPD as one of their main assessment methods to measure tactile acuity. In Study 1 and 3 the MCTB was used to study the correlations of tactile acuity and motor control impairment, as well as the RMDQ to evaluate functional impairments throughout daily activities. Study 4 also used the RMDQ, along with the Brief Pain Inventory and different scales and diaries to reflect the effects on their daily activities and pain levels. Unfortunately the authors did not include TPD testing or any other objective, physical measure within this study. To determine whether there is a relation between tactile acuity and tactile threshold, the authors of Study 2 and 5 assessed tactile thresholds using different filaments to distinguish a pressure value of mg applied to the skin of the lower back until the patient reports a sensation. In Study 5 the authors addressed the matter from another angle and tested body perception. In this examination patients were asked to draw the outline of their posterior back and vertebras on a paper.
A variety of assessment methods were applied in the five studies. Due to the novelty of this topic not all of those measurements have been fully researched on reliability and validity. The results have to be considered critically.

Participants: The sample sizes of participants varies a lot within these five papers. Study 1 included 39 NSLBP patients, which did not have to match the usual 3 months but were accepted with only six weeks of NSLBP. Study 2 included 19 volunteers with CNSLBP and a control group of 19 healthy volunteers, Study 3 included 45 (20 males) with CNSLBP and 20 males without any back pain history within the past two years as a control group.
Study 4 only tested three single individuals, which all suffered from CNSLBP. Within Study 5 a sample of six (three males) CNSLPB patients was compared to ten (five males) healthy individuals as a control group. The samples were rather small, especially in Study 4 and 5 under ten patients were tested. The inclusion and exclusion criteria's were close to consistent throughout all five papers.

Interventions: Only two studies were designed for a longitudinal study with intervention (Study 1 and 4). In both studies motor control tasks and tactile acuity tasks were combined and Graphesthesia was used as tactile acuity training intervention.

Results: In Study 2 the authors confirmed their hypothesis that tactile acuity is impaired with CNSLBP patients. Their assessments alongside the testing's from Study 5 showed no correlation between tactile acuity impairment and tactile threshold impairment. This leads to the conclusion that the impaired tactile acuity impairment is caused by a central origin with CNSLBP patients. Another outcome of Study 5 was the correlation of poor tactile acuity and poor body perception. Patients showed poor tactile acuity and poor body perception at the exact localization of their usual back pain. Body perception was assessed by a drawing of their posterior back, a poorly researched assessment.

The connection of MCI and tactile acuity impairment has been significant in Study 3. The higher the TPD testing was, the worse the MCTB outcomes were. The results of Study 2,3 and 5 show that tactile acuity, body perception, motor control and pain go hand in hand with CNSLBP patients. In consideration of creating a treatment plan for CNSLBP patients, all aspects should be included.

Study 1 and 4 went one step further to confirm Graphesthesia as a treatment for tactile acuity. These were outcomes were only partly convincing. In Study 1 the patients group showed significant improvements on TPD, MCBT, RMDQ and PSFS in the primary study. The comparison to the historic control group, which did a similar treatment series but without tactile acuity training, was not convincing. There was no significant difference on MCBT or PSFS outcomes. The only significant improvement of the intervention group was the RMDQ. Unfortunately, there were no results of TPD of the historic control group. These results question the influence of tactile acuity training on MCI. Never the less the RMDQ improved significantly, which means there is an improvement when including tactile acuity training.

The results of the case studies in Study 4 show significant improvements on all assessments, all patients make breakthrough improvements. The main deficiency of the study is, that all patients did the exact same program and the assessments were diverse diaries

and NRS on functionality and pain intensity. Not a single objective, physical assessment was raised. This leads to a lack of knowledge on what changed on a structural level, in order to get the positive outcomes. It shows a good start with an intervention program of this kind. The study opens up many more questions to investigate. The treatment program of Study 4 has to be researched with more objective measures, bigger sample sizes and a control groups to determine whether it is the tactile acuity training which makes a difference or mainly the motor control exercises. How big the role of tactile acuity training is, in the outcomes of Study 4 remains uncertain.

8.4 Conclusion

Patients with CNSLBP demonstrate significant disturbance of tactile acuity. The reviewed research is unanimous on this aspect. The correlation between tactile acuity impairment and body perception is not evidential and remains speculative, due to a lack of research on valid assessments to represent body perception. The results of tactile threshold testing compared to tactile acuity outcomes strengthen the theory of modifications of the body representation on the somatosensory cortex.
All reviewed studies show decreased in TPD outcomes following Graphesthesia training. Graphesthesia occurs to be a valid training approach to improve tactile acuity.

9 EXPERIMENTAL PART

There is growing evidence that is supporting the idea of altered sensory function in people with chronic low back pain, particularly a loss of sensory acuity (Wand et al. 2011). Assessment of tactile acuity in relation to chronic pain has received increasing attention as it is proposed to reflect the response profile of neurons with the primary somatosensory cortex and may signify disruption of cortical maps specific to the body part. (Wand, 2010) Earlier studies concerning sensory retraining have investigated the effects of motor control training in combination with the training of tactile acuity. These studies were reviewed in the literature part of this thesis (study 1 and study 4)

The experimental part of this thesis was designed to test whether a four week period of tactile acuity training would influence the sensory acuity of people with CNSLBP. Graphesthesia was used as the method of training tactile acuity of the lower back and Two Point Discrimination test was used to measure tactile acuity prior and post intervention.

The specific research questions investigated in this experimental part were as follows:

1. Do patients with CNSLBP demonstrate disturbances in lumbar two point discrimination and back perception?
2. Is there a connection between Two Point Discrimination detection thresholds and Fremantle Back Awareness Questionnaire scores?
3. How does a four week duration of Graphesthesia home training influence the Two Point Discrimination values of CNSLBP patients?
4. How is Graphesthesia as a form of home training for CNSLBP patients?

9.1 Experiment Design

This experiment was designed to be quantitative study however, due to large dropout rate during the intervention period, a longitudinal case study design was applied to

the remaining participants. The experiment design was carefully planned and received ethical approval from the Satakorkea Universities Ethics committee (APPENDIX B).

A flow chart of the experimental design is presented in Figure 3. CNSLBP patients were recruited to take part in the study in the fall of 2016. Before intervention demographic data and Two Point Discrimination measures were obtained from all participants. Additionally patients completed the Roland Morris Disability Questionnaire and Fremantle Back Awareness Questionnaire. The implementation in the form of Graphesthesia home training was designed to take happen in a four week time scale. Re-testing took place directly after the intervention period. Same measures were repeated. Participants that consistently trained Graphesthesia throughout the four week time scale were included in the final data evaluation. The practicality of Graphesthesia as a form of tactile acuity home training was evaluated through the use of patient qualitative feedback.

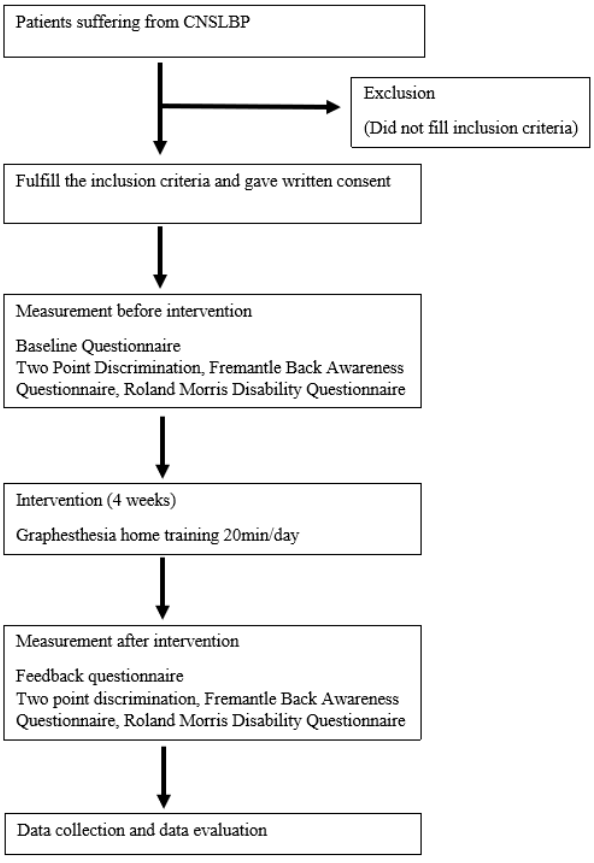

Figure 3. Flow chart of Experiment design

9.2 Satakunta Back Association

The experimental part of this thesis is done in cooperation with Satakunta Back Association. The Satakunta Back Association (Satakunnan Selkäyhdistys) was founded in 1997 and is ran mainly by volunteer work. There is currently approximately 200 members that are also the primary contributors to financial income of the association. The city of Pori supports the association by funding some of the activities and by providing work premises for the association. (Lohivuo, personal communication on 01.04.2016)

Main purpose of the association is to provide helpful information and support to people that have or have had any type of back pain in the past. Weekly exercise groups are implemented and are open for the members of the association to take part in. Lectures are organized once a month that deal with different topics to do with back pain. The lectures are free and open for anyone to take part in. (Website of Satakunnan Selkäyhdistys, 2017)

9.3 Participants

Satakunta Back Association took responsibility over reaching out and contacting potential participants to take part in the study. An advertisement of the experiment was published in the Hyvä selkä magazine, which is directed to the client group including of people with back problems. Leaflets concerning information about the experiment were printed and distributed to various back pain patients at specific clinics around the Pori region.

Participants were required to fill a few criteria to be able to take part in the experiment. To be eligible for inclusion, participants had to report of chronic low back pain of at least 3 months duration and to be over 18 years old. Additionally, participants were required to be able to lie down in prone position without experiencing pain and have someone at home to enable Graphesthesia training.

A total of 13 participants from the Satakunta region signed up for the experiment. The age of the participants ranged from 37-84 years. The participants consisted of 10 women and 3 men and all reported of experiencing low back pain >6 months. Due to a large dropout rate, only two participants were included in the final data analysis process.

9.4 Measures

Two questionnaires were selected, first one concerning the participants degree of disability (Roland Morris Disability Questionnaire) and second one concerning body perception (Fremantle Back Awareness Questionnaire). One physical test (Two Point Discrimination Test) was chosen to measure the tactile acuity. The questionnaires as well as the Two Point Discrimination test were completed in the beginning and repeated in the end of the experiment. Additional questionnaires (Baseline and Feedback Questionnaires) were provided separately in the beginning and at the end of the experiment.

Baseline Questionnaire was structured by the examiner. The questionnaire included of questions concerning the demographic characteristics of the participants. Questions concerned information about the age, gender, pain origin and duration, pain intensity (Numeric Pain Rating Scale), pain mapping. (APPENDIX C)

Roland Morris Disability Questionnaire (RMDQ) is a widely used health status measure for low back pain (APPENDIX D). The RMDQ has been used in research as well as in clinical practice. The patient is asked to tick a statement when it applies to him or her that specific day. The questionnaire gives an idea of the level of disability and enables to follow the changes in the patients functioning. The scoring is calculated based on the sum of the ticked boxes. The score ranges from 0 (no disability) to 24 (maximum disability). The normative data indicates a mean score of 12.1 for patients with non-specific low back pain of >6 weeks. The RMDQ is limited in the sense that it only covers specific physical problems, and not psychological or social problems. (Roland, Fairbank, 2000)

The Fremantle Back Awareness Questionnaire (FreBAQ) was originally developed as a quick and simple way of measuring back specific body perception in people with chronic low back pain (APPENDIX E). The questionnaire is a psychometrically found way of assessing altered self-perception. (Wand et al. 2014) The questionnaire consists of nine descriptions of how back pain patients have described how their backs to feel to them. The patient is asked to indicate the degree as to how they relate with the description when they are experiencing back pain. The score ranges from 0 (no perceived problems with self-perception) to 36 (maximum points; disrupted self-perception). The FreBAQ is a rather recently developed way of assessing back perception and has therefore not yet been studied a lot. The most recent study concerning the reliability of the questionnaire concludes that the questionnaire has acceptable internal consistency and good test-retest reliability, and was functional on the category rating scale.(Nishigami et al. 2017) The FreBAQ was available only in English and was therefore translated into Finnish before distributed to the participants.

The Feedback Questionnaire included of questions aimed to collect qualitative feedback of the participants experiences on Graphesthesia home training. Pain intensity (Numeric Pain Rating Scale) was repeated (APPENDIX F).

Two Point Discrimination test (TPD) is a reliable and commonly used method used to measure tactile spatial acuity. The idea behind the testing is to assess cutaneous innervation and central somatosensory function. TPD measures the individuals ability to perceive two points of stimuli presented simultaneously (Figure 4).

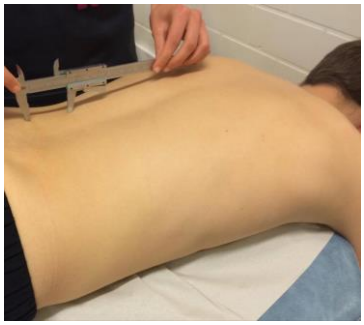

Figure 4 Two Point Discrimination test (TPD) (Salerto,2016)

The measured distance will vary depending on the body part being tested and should be compared to normative data. (Luomajoki, 2010) Areas of the body such as hands and the tongue are more sensitive to outside stimuli in contrast to the lower extremities

and the back. The average TPD detection threshold of the back range around 40-60mm. A TPD value of >60mm is considered to be related with sensory loss of the back. (Mørch et al. 2010)

9.5 Graphesthesia

The idea behind Graphesthesia training is to train the ability to recognize letters or numbers traced on the skin by purely the sensation of touch. The recognition of the figures requires careful concentration on the tactile stimuli applied on the skin of a specific body part. By increasing the amount of stimulation applied on an area on the body, alterations may be made in the cortical representation of the specific body part in the homunculus. (Mørch et al. 2010)

Participants were instructed to have their partners at home to trace upper case letters of the alphabet on both sides of their lower back, however not to extend over the spine (Figure 5). The letters were to be drawn in a random order, in a clear manner with the finger tip of the index finger. Graphesthesia training would begin by having the participant guessing single upper case letters and to proceed to having the letters be traced in smaller size, in slightly faster speed and lastly for more challenge, combining letters to form three letter words (*Table 7*). The participants were instructed to train Graphesthesia every day for 20 minutes in total. The 20 minutes were allowed to be separated into two 10 minute sessions and done at separate times during the day as 20 minutes would be too demanding to complete at once. The duration of 20 minutes of Graphesthesia training a day was set after it was discussed to be an adequate enough amount of time to result in a noticeable increase of stimulation of the back.

Figure 5 Graphesthesia training (Salerto, 2016)

Table 7 Progression of Graphesthesia training

Graphesthesia training
Recognize letters
Progress by size
Progress by speed of drawing
Progress by joining letters to form 3-letter words

9.6 Implementation

The preparation for the experiment was begun in the early fall of 2016. Material concerning the publicizing of the study were made and distributed around the Pori region through the help of Satakunta Back Association. Measuring TPD was trained to ensure consistency, accuracy and reliability.

Participants were invited to the Back Association seminar that took place 18.10.2016. The seminar included of a power point presentation that aimed to educate the participants on the biopsychological model of CNSLBP that integrated the cortical changes and disturbances in body perception (APPENDIX G). The presentation also explained the goals and instructions concerning Graphesthesia training and the study. Videos and written instructions of Graphesthesia training were prepared and presented to the participants (APPENDIX H). Following the power point presentation, participants filled the Baseline Questionnaire, RMDQ and FreBAQ. All material and presentations were completed in Finnish.

A total of 26 people attended the seminar and listened to the lecture. Total of 15 people signed the consent concerning the participation of the experiment (APPENDIX I). Two participants were directly excluded from the experiment due to not being able to train Graphesthesia as they did not have a partner at home to enable Graphesthesia training.

Two point discrimination test was carried out during the same night from all the participants. For the testing subjects were positioned comfortably in prone lying with their back exposed. Testing was done privately in a separate room where noise was kept low and distractions were minimized. Pillows were positioned under the stomach with some subjects to reduce excess lumbar lordosis and flatten the lumbar spine. A set of mechanical calipers with the precision of 1mm was lightly applied vertically to the back until the very first contact to the skin. The calipers were parallel to the spine and the transverse process of L3 was maintained in the center of the two calipers. To make sure the participant wasn’t guessing, the distance between the two calipers was randomly and repeatedly increased and decreased until the TPD threshold was defined as the shortest distance between the caliper points at which the participant could clearly

detect two separate points instead of one. Simple instructions were given to the subjects before testing was begun. Subjects were instructed to say “one” if they felt one point touch their back and “two” if they felt two distinctive points in their back. For all subjects, testing was taken separately on the right and left sides of the lower back. The same examiner undertook TPD testing of all participants in the beginning and in the end of the four week intervention period to ensure consistency.

A training diary was prepared and handed out to all the participants where they could keep track of the consistency of training Graphesthesia at home (APPENDIX J). The diary consisted of a calendar for the following four weeks, until the final assessment that took place at the following Back Association seminar on 16/11/2016. In the diary each day included of two boxes that each represented 10 minutes of Graphesthesia training. The participants were instructed to tick a box each time they completed the 10 minutes. This assured and reminded the participants to complete the required 20 minutes of Graphesthesia a day. The diary also had space where the participant could write if they were not able to complete the training and to note down reasons as to why.

10 RESULTS OF THE EXPERIMENTAL PART

The results regarding the experiment were combined and structured to allow for further data analysis. The experiment progression is described and the results are presented and evaluated further. A set of graphs and tables were made to help display the outcomes logically. The results are presented following the order of the experiment research questions.

10.1 Participant Baseline Characteristics

Prior to the 4 week Graphesthesia home training period demographic data of a total of 13 participants was collected. Information concerning the baseline characteristics of

the participants as well as the RMDQ, FreBAQ and TPD scores were combined and summarized in Table 8.

Table 8 Baseline characteristics of participants

Participants (n)	13
Age (years), mean	66.8
Gender (n), Male M, Female F	M: 3 F: 10
Chronic pain duration >6 months (n)	13 (100%)
Working (n)	3
Retired (n)	10
RMQ (/24), mean	9
FreBAQ (/36), mean	12
TPD (mm), mean	73

n: number of participants, RMDQ: Roland Morris Disability Questionnaire, FreBAQ: Fremantle Back Awareness Questionnaire, TPD: Two Point Discrimination test

10.2 Disturbances in lumbar TPD and back perception of CNSLBP patients

The calculated averages of TPD values prior to the intervention were displayed graphically to enable visual inspection of the sensory acuity of 13 CNSLBP patients (Figure 6). Out of 13 participants a total of 10 participants (77%) showed reduced tactile sensitivity in the low back having a TPD value of >60mm.

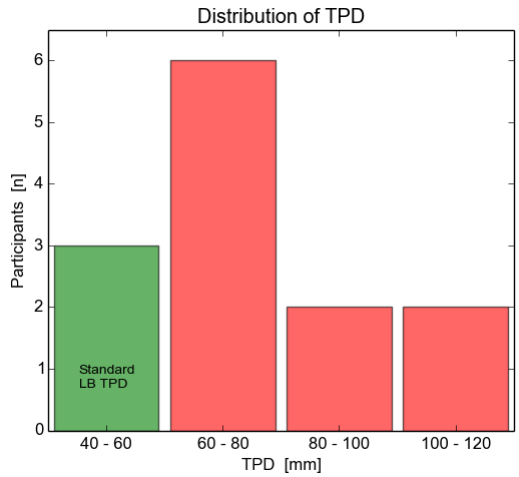

Figure 6 Distribution of TPD thresholds of 13 CNSLBP patients

The FreBAQ scores revealed that all 13 participants reported of disrupted back perception, however at a range of different levels. Out of 13 CNSLBP patients, scores of the FreBAQ ranged between 2/36-20/36 which indicates that perceived back awareness is very individual.

10.3 Connection between TPD values and FreBAQ scores of CNSLBP patients

To address the research question of whether there is a connection between TPD and back perception a scatter graph was made that compared the two variables. As presented in Figure 7, there was no correlation between TPD and the FreBAQ scores. The Pearson correlation coefficient is a measure of linear correlation between two variables. It has a value between +1 and −1, where 1 is total positive linear correlation, 0 is no linear correlation, and −1 is total negative linear correlation. The calculated correlation between TPD and FreBAQ results was -0,059. This confirms that there is no linear correlation between the two variables. Participants with higher TPD values did not thereby necessarily show a higher scoring in the FreBAQ and vice versa.

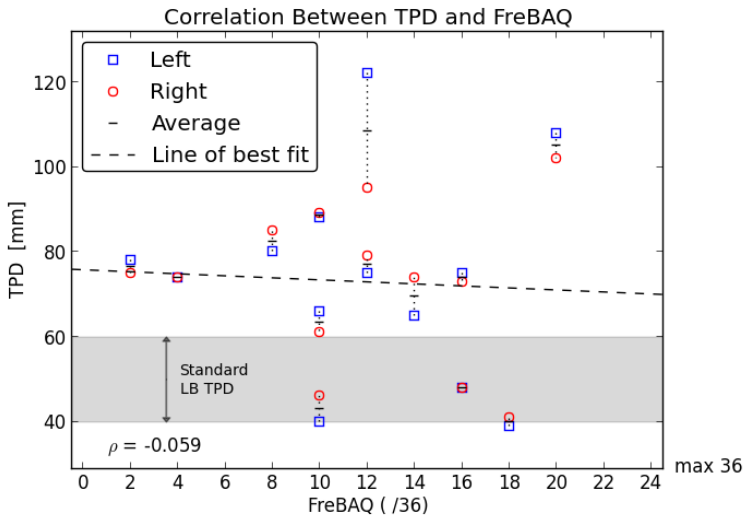

Figure 7 Correlation between TPD and FreBAQ

10.4 Influence of Graphesthesia home training on TPD

During the four week intervention period 10 people did not follow though and left the experiment. At the end of the intervention level of disability (RMDQ), back awareness (FreBAQ) and TPD were recorded from three remaining participants. Figure 8 presents a flow chart of the experiment progression. All returned the training diaries where consistency of Graphesthesia training was reported throughout the four week intervention period. A single case study design was applied to two participants (Case 1 and Case 2) that trained Graphesthesia consistently (20min/day). Case 3 was excluded from the single case study design for not training Graphesthesia consistently and enough (<10 min/day). Qualitative feedback on Graphesthesia training was collected from six participants.

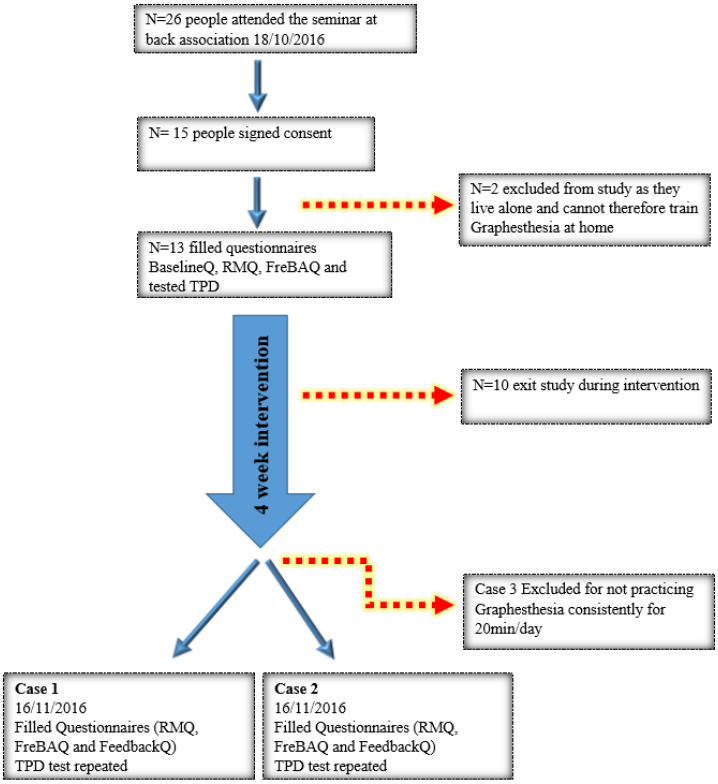

Figure 8 Flow Chart of experiment progression

Outcome measures and detailed feedback of the 4 week Graphesthesia training period were collected from Case 1 and Case 2. Descriptions of the participants, their feedback and their results are summarized below.

Case 1 was a 66 year old retired woman. She has a 9 year history of bilateral back pain which begun due to an accident. She takes pain killers daily as well as during the nights to relieve the pain in the back and to properly relax.

She has tried multiple different treatments to try and relieve the back pain but has not succeeded with any.

She described being interested in new treatment approaches and therefore wanted to take part in the experiment.

Tactile acuity training was new to her and she was skeptical about the effects of it. She trained Graphesthesia consistently every day for 20 minutes as instructed. She reported that the larger letters were somewhat easy to recognize however combination and smaller letters caused difficulty and required much focus. Overall Graphesthesia training felt relaxing and got easier during the 4 week period. 20 minutes of Graphesthesia training a day felt like a long amount of time especially in the beginning.

Table 9 Case 1 Pre and Post intervention outcome measures

Outcome (scores)	Pre intervention	Post intervention
NPRS (0-10)	7	6
FreBAQ(/36)	2	0
RMQ (/24)	4	4
TPD (mm)	76.5	40.5

Case 2 was a 63 year old retired woman. She has a 3 year history of non-specific chronic bilateral low back pain and bilateral buttock pain. She described an initial incident of transferring a family member and experiencing sharp pain in the low back for the first time over a year ago. From thereon she has reported of having frequent bilateral pain in the back and buttocks.

She takes pain killers almost every day, depending on the activities she has been doing earlier.

She reported of having doubts about Graphesthesia training and its benefits on her condition in the beginning of the study. She described Graphesthesia training being surprisingly challenging and tiring. 20 minutes felt like a long amount of time to train Graphesthesia even when split into two separate 10 minute sessions. Recognizing letters got easier during the 4 week intervention. She reported of performing consistently better on the left side of the back than the right.

Table 10 Case 2 Pre and Post intervention outcome measures

Outcome (scores)	Pre intervention	Post intervention
NPRS (0-10)	7	7
FreBAQ(/36)	8	8
RMQ (/24)	10	9
TPD (mm)	82.5	51

TPD values of both participants (Case 1 and Case 2) prior and post intervention are presented in Figure 9. TPD values of the left and right side of the back as well as the averages are displayed for both participants. For Case 1 the TPD detection threshold decreased by 36mm after 4 weeks of Graphesthesia training. For Case 2 the TPD detection threshold decreased by 31.5mm.

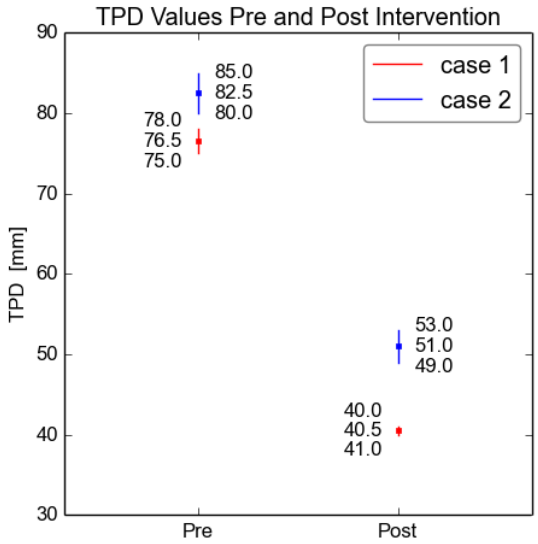

Figure 9 Case 1 and Case 2 TPD values pre and post intervention

Inspection of the collected data indicated no improvement in the clinical status of either of the participants that concluded the four week Graphesthesia home training program. Both participants 1 and 2 reported no significant changes in degree of disability, pain intensity and back perception. TPD detection threshold however improved for both participants post intervention. Both participants showed reduced tactile acuity in the low back prior to the intervention. In the final assessment TPD values of both participants decreased to the level of standard low back TPD. A summary of the results prior and post intervention for both participants are provided in Table 9 and Table 10.

10.5 Graphesthesia as a form of home training for CNSLBP patients

Qualitative feedback regarding Graphesthesia home training was collected from a total of six participants, three of which were contacted post intervention via email. The summarized feedback indicated that Graphesthesia as a form of home training was a

simple way to train tactile acuity however it appeared very time consuming. The duration of 20 minutes felt long for most participants.

Other reoccurring feedback indicated that Graphesthesia training appeared to be surprisingly difficult and exhausting as it required a lot of concentration. Some participants reported lacking motivation to train and doubting the effectivity of the training. Participants reported of having challenges with consistently training due to partner at home not having the time to enable Graphesthesia training.

11 CONCLUSION OF THE EXPERIMENTAL PART

The data collected from 13 CNSLBP patients at the baseline of the experiment support previous findings suggesting that patients with CNSLBP commonly demonstrate specific deficits in sensory function over the lumbar spine and have difficulties in perceiving their backs. High Two Point Discrimination values however proved to not correlate with higher scores on the Fremantle Back Awareness questionnaire.

Due to a large drop out percentage a single case study design was applied to two people with CNSLBP and it appeared that neither of the participants benefitted from the program. The participants showed no significant changes in the outcomes between the baseline and post intervention for the three measures: degree of disability, pain intensity and back perception. Both of the participants however showed significant improvement in the Two Point Discrimination detection thresholds of the low back. Two Point Discrimination detection thresholds improved noticeably for both of the participants suggesting that consistent increase of tactile stimulation in the form of Graphesthesia training, improves the tactile acuity of the low back. The duration of 20 min a day of Graphesthesia training proved to be an adequate amount of time to achieve a sufficient increase of tactile stimulation in the low back to improve the Two Point Discrimination detection threshold.

Based on participant feedback Graphesthesia as a form of home training proved to be challenging due to it being very time consuming, it being dependent on a another person and participants lacking of motivation to consistently train for 20 minutes a day.

12 DISCUSSION OF THE EXPERIMENTAL PART

The aim of the experimental part of this thesis was to describe a tactile acuity training approach in the form of Graphesthesia training for the management of CNSLBP and to document the outcomes of people participating in the experiment. The findings of this experiment suggest that training Graphesthesia 20 minutes a day for the duration of four weeks improves the tactile acuity of the low back. The four week duration of Graphesthesia training however does not appear to have an influence on pain intensity or back perception. This raises the question whether four weeks of tactile acuity training is too short of a duration to normalize the cortical representations of the back, and to study the long term effects of Graphesthesia.

Although this experiment was carefully prepared, there were some evident limitations and shortcomings that should be taken into consideration. The results presented need to be interpreted in light of these experimental limitations. The most obvious limitation in the interpretation of the experiment was the small amount of participants that completed the whole experimental process. The findings of two people are not enough to base solid conclusions on however, they give good indication on the impact Graphesthesia home training has on Two Point Discrimination. A larger population of the experimental group would increase variety and thereby reliability of the experimental findings. The small number of participants that concluded the whole experiment limited the ability to utilize sophisticated statistical methodologies and therefore examine the complex relationships between the outcome measures. Future research would benefit from the use of a larger sample of clinical participants.

Another experimental limitation appeared to be strongly related to the organization of the baseline seminar. The seminar included of many important aspects regarding the experiment, number one being the role it had in the patient education and motivation.

The education about the theory behind chronic pain, introduction to the experiment and Graphesthesia were all included in one presentation which was presented to the participants. TPD testing was undertaken by one examiner during the same night. Due to the busy schedule, very limited time was left for participants to ask clarifying questions and to have one on one time with the examiner. Understanding the aims of treatment play a crucial role in the success of it and in the motivation of the participants. This may explain the reason behind the large number of participants that dropped out during the intervention.

Furthermore an aspect to take into account was the age range of the participants. Earlier studies that have collaborated with CNSLBP patients often have included an age range in the study inclusion criteria. Typically the maximum age of participants range around 60-70 years of age. The demographic data collected in the baseline of this experiment showed that the ages of the participants ranged between 37-84 years. The mean age of the 13 participants that signed the consent regarding the experiment was calculated at 66.8 years. 11 out of the total of 13 participants were over 60 years of age. This may also have had an impact on the large number of drop outs during the intervention as elder participants may not have the capacity and energy to commit to an extensive experiment such as this. The feedback collected post intervention support this idea, as a reason for dropping out was commonly reported as lack of time or exercises being too demanding. Graphesthesia training being dependent on another person also appeared to limit the consistency of training.

The measures selected for this experiment were relevant in relation to the aims of the thesis and the set experiment research questions. The validity and reliability of the selected questionnaires were confirmed. The FreBAQ is a recently developed way of assessing back perception of LBP patients. It is a quick and good assessment method however, in this experiment not all participants necessarily understood the questionnaire and the included statements on back perception. Due to the hectic schedule and limited time during the baseline seminar, there was no time to explain the questionnaire in detail to the participants. This may have limited the reliability of the results collected through this questionnaire. The results concerning the correlation between TPD and back perception therefore need to be interpreted critically as FreBAQ was the only measure used to collect information on back perception of the participants.

TPD has been proven to be a reliable method to assess tactile acuity. Consistency in TPD testing was achieved by having one examiner measure TPD values of every participant prior and post intervention. This assured that there were no differences in the measuring technique used. To avoid observer bias TPD values collected prior intervention were not available during the time of the intervention nor retesting so that examiner could not refer to the results. An examiner blind to the experiment would have been necessary to have completely eliminated potential observer unconscious bias. To improve reliability of testing TPD measures should be measured several times during a certain time period such as a week. This would ensure TPD reliability if the values remained consistent throughout independent from the day of testing. This particular experimental design did not allow for such extensive testing due to the limited time and tight schedule.

A limitation regarding the experiment design is that only one physical test was implemented which had to do with measuring tactile acuity. Motor control was not considered nor assessed which is an important factor to examine in relation to the topic concerning of cortical changes, body perception and tactile acuity. The influence of Graphesthesia tactile acuity training on motor control therefore was left unknown. One examiner being responsible of all testing restricted the amount of assessments implemented. The lumbar movement control test battery (Luomajoki, H., 2010) would be a beneficial measure to consider including in future experiments to evaluate motor control impairment of CNSLBP patients in relation to body perception and tactile acuity.

13 DISCUSSION

The amount of existing literature available concerning chronic non-specific low back pain, cortical changes and tactile acuity was limited due to this being a new area of focus in the study of chronic low back pain. More existing literature was available on other chronic pain conditions such as CRPS and phantom limb pain in relation to sensory discrimination training. Regardless, a sufficient amount of literature was retrieved and reviewed. The findings suggest that in order to achieve successful results in CNSLBP treatment, the disrupted cortical representations should be targeted and aimed to normalize through sensory retraining. Studies that have presented the best results in managing CNSLBP have been achieved through combining tactile acuity training with motor control exercises and pain education.

One of the strengths of this thesis was that it was designed to determine the role of Graphesthesia training alone in relation to tactile acuity and CNSLBP. Previous studies have all combined therapeutic interventions which make the interpretation of the results more challenging. Focusing on one intervention method gives indication of the exact role it plays. When testing several elements, including pain education, sensory retraining and motor retraining, it is not clear which components were responsible of the improvements.

Although this thesis reached its aims there are some unavoidable limitations that need to be considered. The literature review and experiment were conducted at the same time and in different countries, which limited the guidance of the literature research to the implementation of the experiment. The measures and methods used in the existing studies did not all correlate with the measures used in the experiment which added difficulty in the comparison of the findings. Two point discrimination was a measure that recurred throughout as it was included as one of the inclusion criteria during the literature review selection process.

Methods used to assess back perception also varied a lot. The reliability and validity of these assessment methods have not been fully established and therefore results need to be interpreted with caution. The Fremantle Back Awareness Questionnaire was not

used in other studies other than the experiment. This did not allow comparison between the results and weakens the reliability of the collected data.

The results of the experiment alone are not enough to conclude that Graphesthesia has an influence on Two Point Discrimination due to the experiment being a case study of two CNSLBP patients. The results collected from the case study however, do correlate with existing data. Combined findings suggest that tactile acuity seems very responsive to training. Training Graphesthesia has an evident influence on tactile acuity of the trained body part and improves the low back Two Point Discrimination detection thresholds of CNSLBP patients. Even though Graphesthesia training has a positive impact on tactile acuity, there is still not enough evidence to determine whether Graphesthesia training is contributing to the management of CNSLBP. Further research is necessary in order to explore the long term effects of Graphesthesia training.

We suggest future research to further study the required intensity and duration of Graphesthesia training in order to achieve the required extent to trigger reorganization of the cortical maps. Whether Graphesthesia training as the form of sensory training is enough to influence reorganization of the cortical maps, is another aspect for further research. The relationship between tactile acuity and motor control should also be considered. It would be worthwhile to study how Graphesthesia training may contribute to the normalization of lumbopelvic proprioception and motor control.

Working on this thesis has deepened the level of our knowledge regarding chronic pain, CNSLBP, cortical behavior in relation to pain experience and the treatment methods that should be considered in the future when working with chronic pain patients. Through the experiment valuable experience was gained and big lessons were learned regarding the importance of motivating, forming a connection and educating the chronic pain patients. We learned that CNSLBP is multidimensional illness that needs to be carefully approached. TPD is a valid measure to include in the assessment of a CNSLBP patient. Tactile impairments should be noted and sensory retraining considered to be included in the rehabilitation program.

14 CONCLUSION

The aims of this joint thesis was to study Graphesthesia training and the relation between CNSLBP and tactile acuity. In conclusion, the combined findings of the literature review and the experiment indicate that CNSLBP patients demonstrate reduced tactile acuity and body perception of the back. These results are supportive of the notion that CNSLBP is characterized by dysfunction of sensory processing of information from the painful area. Furthermore the results suggest that a four week duration of tactile acuity home training in the form of Graphesthesia improves the Two Point Discrimination outcomes of CNSLBP patients. The results suggest that improvement in tactile acuity alone does not however improve the chronic pain state.

15 REFLECTION ON THE JOINT THESIS PROCESS

This joint thesis was the first thesis in which the Zurich University of Applied Sciences (ZHAW) and Satakunta University of Applied Sciences (SAMK) collaborated in. Piloting a thesis cooperation such as this brought with it some challenges as well as great benefits.

The cooperation and communication between the Universities ran smoothly throughout the whole process. Skype meetings were arranged in the beginning of the thesis process where both students and supervising teachers took part in. These meetings helped in the planning the frame work of the thesis and understanding the requirements the Universities. Both Universities were able to compromise in some aspects of the thesis requirements. Writing the thesis was arranged so that to a certain extent students shared a file online where all inclusions and changes were updated. Later on in the thesis process two separate files were created in order to fulfill the specific requirements of the Universities.

Overall this collaboration allowed us to develop our international networking and cooperation skills. The collaboration of two Universities and having two advisors enabled the possibility to incorporate different approaches and gain perspectives of more

than one academic advisor. We were able to broaden our knowledge and join together the strengths of both University physiotherapy programs. This opened up the possibility to approach the chosen topic from two different educational angles. All of these aspects made working on thesis a more international and interesting process.
Different schedules, educational systems and working in different countries brought with it some challenges which slowed down the thesis process noticeably. This was however expected and adjustments were made accordingly.

To develop the international joint thesis process in the future an European guideline and layout designed to combine the requirements of two Universities would be beneficial.

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APPENDIX A

STROBE STATEMENT RESULTS

	Gutknecht et al. (2014)	**Wand et al. (2010)**	**Luomajoki et al. (2009)**	**Wand et al. (2011)**	**Moseley (2008)**
1. a	YES	YES	YES	YES	NO
b	YES	YES	YES	YES	YES
2	YES	YES	YES	NO	YES
3	YES	YES	YES	NO	YES
4	YES	YES	YES	YES	NO
5	NO	YES	YES	YES	NO
6 a	YES	YES	YES	YES	YES
b	YES	YES	-	NO	-
7	YES	YES	YES	YES	YES
8	YES	NO	YES	YES	YES
9	NO	NO	NO	YES	NO
10	YES	NO	NO	NO	NO
11	YES	NO	NO	YES	YES
12 a	YES	YES	YES	YES	NO
b	YES	YES	YES	YES	NO
c	YES	YES	YES	YES	YES
d	YES	YES	YES	YES	YES
e	YES	YES	YES	YES	NO
13 a	YES	YES	YES	YES	YES
b	YES	YES	YES	YES	YES

c	YES	YES	NO	NO	NO
14 a	NO	YES	YES	YES	YES
b	YES	YES	NO	NO	YES
c	NO	-	-	YES	-
15	YES	YES	YES	YES	YES
16 a	NO	YES	YES	YES	YES
b	YES	NO	NO	YES	YES
c	-	-	-	-	-
17	YES	YES	YES	YES	NO
18	YES	YES	YES	YES	YES
19	NO	YES	YES	YES	YES
20	NO	YES	YES	YES	YES
21	NO	YES	YES	YES	YES
22	YES	YES	YES	YES	YES
TOTAL	**25/33** **75,8%**	**27/32** **84,4%**	**25/31** **80,6%**	**27/33** **81,8%**	**21/31** **67,7%**

APPENDIX B

ETHICAL APPROVAL

Satakorkean eettinen toimikunta 21.10.2016

Lausunto "Graphesthesia Tactile Acuity Training with Non-Specific Chronic Low Back Pain Patients", tekijä Fysioterapian englanninkielisen koulutusohjelman opiskelija Sara Salerto, Satakunnan ammattikorkeakoulu, ohjaaja lehtori Maija Kangasperko, Satakunnan ammattikorkeakoulu Sosiaali- ja terveysala Pori

Tausta: Fysioterapian koulutukseen liittyvässä opinnäytetyössä opiskelijan tarkoituksena on tutkia kivun hoitoa Graphesthesia-harjoitusmenetelmän avulla. Opinnäytetyön tutkimuksellinen osuus koostuu neljän viikon aikana suoritettavista Graphesthesia kotiharjoitteista sekä tutkimuksen alussa ja lopussa tehtävistä selän kahden pisteen erottelukyvyn testauksista. Tutkimuksen alussa ja lopussa osallistujat täyttävät myös taustatietolomakkeen sekä Rolland Morris Disability- ja Fremantle Back Awareness kyselylomakkeet. Satakunnan Selkäyhdistys auttaa opiskelijaa tavoittamaan osallistujat selkätutkimukseen.

Arvio: Opinnäytetyön suunnitelmassa opiskelija tuo esille opinnäytetyön tarkoituksen ja keskeiset tavoitteet. Opiskelija on sitoutunut noudattamaan Tutkimuseettisen neuvottelukunnan (TENK) laatimia, *Humanistisen, yhteiskuntatieteellisen ja käyttäytymistieteellisen tutkimuksen eettisiä periaatteita*. Tutkimusetiikkaan liittyviä asioita ja osatekijöitä opiskelija on ottanut huomioon opinnäytetyönsä suunnitelmassa.

Päätös: Lausuntopyyntöasiakirjojen näkökulmasta tutkimukseen liittyviä eettisiä ongelmia on pyritty kattavasti huomioimaan tutkimusta suunniteltaessa. Toimikunta ei näe esteitä tutkimuksen toteuttamiselle.

Anne Kärki, Satakunnan Ihmistieteellisen eettisen toimikunnan puheenjohtaja

APPENDIX C

BASELINE QUESTIONNAIRE

Nimi _____

Puhelin numero _____

Sähköposti osoite_____

Ikä _____

Sukupuoli **Mies** **Nainen**

1. Mikä on nykyinen työtilanteesi? Minkälaista työtä teet?

_____

2. Jos olette sairauslomalla, kuinka pitkään sairausloma on jatkunut?

_____

3. Minkälainen on mielestäsi fyysinen kuntosi?
hyvä
melko hyvä
keskitasoinen
melko huono
huono

4. Milloin selkäkivut ovat alkaneet?

_____

_____

5. Millaiset asiat helpottavat kipuanne?

_____

_____

6. Millaiset asiat pahentavat kipuanne?

_____

_____

7. Mikä on teidän käsityksenne kivun syystä tai aiheuttajasta?

_____

_____

8. Käytättekö kipulääkkeitä kipunne hoitoon?

_____

9. Onko teillä vaikeuksia nukahtaa illalla kipujen vuoksi? Jos on, niin kuinka usein?

_____

10. Heräättekö kesken unienne kipujen vuoksi? Jos herätte, kuinka usein?

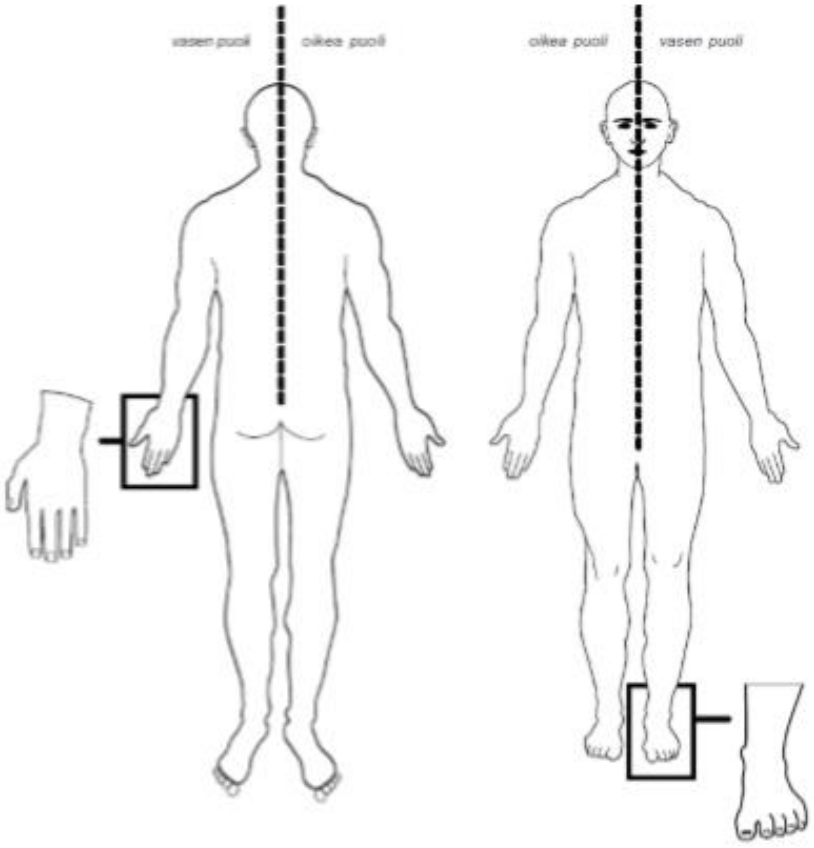
_____

11. Kuinka usein harrastat liikuntaa vapaa-aikanasi vähintään puolen tunnin ajan?
useita kertoja päivässä
noin kerran päivässä
4-6 kertaa viikossa
2-3 kertaa viikossa
kerran viikossa
harvemmin
en lainkaan

12. Alla on numeroasteikko, 0 merkitsee tilannetta, jossa kipua ei ole lainkaan ja 10 on voimakkain mahdollinen kuviteltavissa oleva kipu. Merkitkää alla olevalle viivalle kuinka voimakas kipunne on silloin kun se on pahimmillaan. Merkitkää myös samalle viivalle kuinka voimakas kipunne on silloin kun se vähäisimmillään.

Ei kipua 0 1 2 3 4 5 6 7 8 9 10 Pahin mahdollinen kipu

13. Seuraavan piirroksen avulla on tarkoitus selvittää missä kipunne on. Piirtäkää kuvaan ne kohdat joissa teillä on kipua tai tuntohäiriötä. Olkaa huolellinen, älkää sekoittako vasenta ja oikeaa puolta keskenään. Käyttäkää mielellään kahta eri väriä. Punainen kipuun ja sininen puutumiseen ja tunnottomuuteen. Jos oire on voimakas, värittäkää voimakkaasti, lievään oireeseen kevyemmin.



APPENDIX D

ROLAND MORRIS DISABILITY QUESTIONNAIRE

Selkäoirekysely (RDQ) – Alkukysely

Nimi _____

Syntymäaika | | | | | 1 | 9 | | |

Kyselyn täyttöpäivämäärä | | | | | 2 | 0 | | |

Silloin kun selkäsi on kipeä, sinun saattaa olla vaikea tehdä joitakin asioita, joita normaalisti teet. – Tämä lista sisältää muutamia lauseita, joita ihmiset ovat käyttäneet kuvailemaan itseään silloin, kun heillä on selkäkipuja. Kun luet nuo lauseet, saatat huomata, että jotkut erottuvat joukosta, koska ne kuvaavat sinua juuri nyt. Kun luet listaa läpi, ajattele itseäsi juuri nyt. Kun tulet sellaiseen lauseeseen, joka kuvaa sinua juuri nyt, laita rasti ruutuun. Jos lause ei kuvaa sinua juuri nyt, jätä rastin paikka tyhjäksi ja jatka seuraavaan.

Muista siis, että rastitat lauseen vain jos olet varma, että se kuvaa sinua juuri nyt.

	pitää paikkansa
1. Selkävaivan takia vietän suurimman osan ajastani kotona	
2. Muutan usein asentoa saadakseni sen hyväksi selälle	
3. Kävelen tavallista hitaammin selkäni vuoksi	
4. Selkäni vuoksi en tee sellaista askareita, joita normaalisti teen vapaa-aikanani	
5. Käytän selkäni vuoksi kaidetta apuna portaita noustessani	
6. Selkäni vuoksi asetun makuulle lepäämään tavallista useimmin	
7. Joudun selkäni vuoksi ottamaan tukea päästäkseni ylös nojatuolista	
8. Yritän selkäni vuoksi saada muut tekemään asioita puolestani	
9. Pukeudun selkävaivani takia tavallista hitaammin	
10. Nousen ylös seisaalleni vain lyhyeksi aikaa selkävaivani vuoksi	
11. Yritän olla kumartumatta tai polvistumatta selkävaivani vuoksi	
12. Minun on vaikea nousta tuolista selkävaivani vuoksi	
13. Selkäni on kivulias kaiken aikaa	
14. Minun on vaikea kääntyä vuoteessa selkävaivani takia	
15. Ruokahaluni ei ole selkävaivani vuoksi kovin hyvä	
16. Minun vaikea vetää sukkia jalkaani selkävaivani vuoksi	
17. Kävelen selkävaivani vuoksi vain lyhyitä matkoja kerrallaan	
18. Nukun huonosti selkävaivani takia	
19. Tarvitsen selkävaivani vuoksi toisen henkilön apua pukeutuessani	
20. Istun paikallani suurimman osan päivästä selkävaivani vuoksi	
21. Vältän raskaita hommia vapaa-aikanani selkävaivani vuoksi	
22. Olen selkävaivani vuoksi tavallista ärtyisämpi ja pahantuulisempi seurustellessani muiden ihmisten kanssa	
23. Kuljen portaita ylös tavallista hitaammin selkävaivani vuoksi	
24. Olen vuoteessa suurimman osan aikaa selkäni vuoksi	

APPENDIX E

FREMANTLE BACK AWARENESS QUESTIONNAIRE

Fremantle kysely

Alla on lueteltuna tuntemuksia, joita selkäpotilaat ovat kuvanneet kokeneensa. Käyttäen asteikkoa 0-4, merkitse, miten kirjatut kuvaukset sopivat sinuun, kun kärsit selkäkivusta.

0 = Ei koskaan tunnu tältä
1 = Harvoin tuntuu tältä
2 = Silloin tällöin tuntuu tältä
3 = Usein tuntuu tältä
4 = Aina, tai suurimman osan ajasta tuntuu tältä

	Ei koskaan	Harvoin	Silloin tällöin	Usein	Aina
1. Selkäni tuntuu kuin se ei olisi osa minua.	0	1	2	3	4
2. Minun täytyy keskittyä tarkasti selkääni jotta pystyn liikuttamaan sitä haluamani mukaan.	0	1	2	3	4
3. Minusta tuntuu joskus siltä että en pysty kontrolloimaan enkä liikuttamaan selkääni hallitusti.	0	1	2	3	4
4. Liikkuessani en tiedä miten ja kuinka paljon selkäni liikkuu.	0	1	2	3	4
5. Liikkuessani en ole varma missä asennossa selkäni tarkalleen on.	0	1	2	3	4
6. En kykene hahmottamaan selkääni täysin tarkasti.	0	1	2	3	4
7. Selkäni tuntuu kuin se olisi suurentunut (turvonnut).	0	1	2	3	4
8. Selkäni tuntuu kuin se olisi kutistunut/pienentynyt.	0	1	2	3	4
9. Selkäni tuntuu toispuoleiselta(epäsymmetriseltä).	0	1	2	3	4

FEEDBACK QUESTIONNAIRE

Nimi _____

Ikä _____

Puhelinnumero _____

Sukupuoli Mies Nainen

Tein harjoitteita _____ viikossa.

A) 0-3 kertaa
B) 3-5 kertaa
C) Joka päivä

Tein harjoitteita _____ minuuttia päivässä.

A) Alle 10min
B) 10-15min
C) 20min

Harjoitteiden tekemiseen annettu ohjeistus 20 min päivässä tuntui _____.

A) lyhyeltä
B) sopivalta
C) pitkältä

Ilmenikö harjoitteiden tekemisessä mitään rajoittavia tekijöitä? Jos niin, mitä?

_____

Onko selän hahmotus mielestänne parantunut?

A) Ei yhtään
B) Vain vähän
C) Jonkin verran
D) Huomattavasti

Onko selkäkipu vähentynyt?

A) Ei yhtään
B) Vain vähän
C) Jonkin verran
D) Huomattavasti

Kerro vapaasti mitä mieltä olitte tehdyistä harjoitteista. Olivatko harjoitteet mielestänne hyödyllisiä? Helppoja? Haastavia?

_____
_____
_____
_____

Koitteko tutkimuksen alussa graphesthesia harjoitteet luotettavana hoitomenetelmänä vai herättivätkö ne ennakkoluuloja? Entä tutkimuksen jälkeen?

_____
_____
_____

Olivatko annetut harjoitteiden ohjeistukset mielestänne selkeitä?

_____
_____

Mitä hyötyä koitte tutkimuksesta olevan teille?

_____
_____

Voisitteko kuvitella jatkavanne harjoitteita jatkossa?

_____
_____

Minkälainen on mielestäsi fyysinen kuntosi?
hyvä
melko hyvä
keskitasoinen
melko huono
huono

Käytättekö kipulääkkeitä kipunne hoitoon?

_____

Kuinka usein harrastat liikuntaa vapaa-aikanasi vähintään puolen tunnin ajan?
useita kertoja päivässä
noin kerran päivässä
4-6 kertaa viikossa
2-3 kertaa viikossa
kerran viikossa
harvemmin
en lainkaan

12. Alla on numeroasteikko, 0 merkitsee tilannetta, jossa kipua ei ole lainkaan ja 10 on voimakkain mahdollinen kuviteltavissa oleva kipu. Merkitkää alla olevalle viivalle kuinka voimakas kipunne on silloin kun se on pahimmillaan. Merkitkää myös samalle viivalle kuinka voimakas kipunne on silloin kun se vähäisimmillään.

Ei kipua 0 1 2 3 4 5 6 7 8 9 10 Pahin mahdollinen kipu

BACK ASSOCIATION POWER POINT PRESENTATION

Tervetuloa!

Tutkimuksen aiheena Krooninen selkäkipu

SATAKUNNAN AMMATTIKORKEAKOULU (SAMK) JA ZURICH UNIVERSITY OF APPLIED SCIENCES (ZHAW)

OPINNÄYTETYÖN OHJAAJINA TOIMIVAT LEHTORI MAIJA KANGASPERKO JA PROFESSORI HANNU LUOMAJOKI.

Zurich University of Applied Sciences

samk Satakunnan ammattikorkeakoulu Satakunta University of Applied Sciences

zh aw

Satakunnan selkäyhdistys

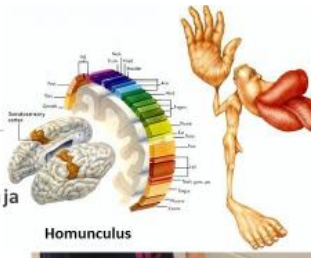
Fysioterapiaopiskelija Sara Salerto

Krooninen kipu

- Aivotutkimus on edennyt viimevuosina huimin askelin ja kivun tutkimuksessa ennen kaikkea aivojen osuus kivun käsittelyssä on noussut tärkeään asemaan.
- Krooninen kipu muuttaa aivoja.
- Parannuskeino on aivojen uudelleenkoulutus.
- Pitkittyneeseen selkäkipuoireistoon voi liittyä niin toiminnallisia kuin rakenteellisiakin muutoksia aivoissa. Tärkeätä on ennalta ehkäistä muutoksia hyvällä hoidolla ja kivunhallinnalla. Pitkänkin kiputilan jälkeen muutokset voivat kuitenkin olla palautettavissa tehokkaan kivunhallinnan avulla.

Aivot- Sensorinen korteksi

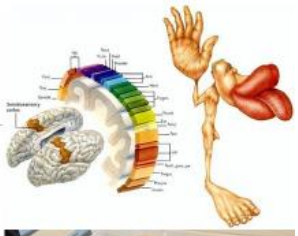
- Homunculus kuvaa eri ruumiinosien edustusalueita
- Sormien ja kasvojen alue ovat suuria alueita homunculuksella ja näin ne ovat tarkkoja erottelukyvyltään.
- Selkä on vain pieni piste homunculuksella.
- Tutkimukset ovat todistaneet että krooninen selkäkipu muuttaa kyseisen ruumiinalueen hahmotuskykyä. → tämä tarkoittaa kliinisesti sitä että potilas ei enään hahmota ruumiinaluetta yhtä hyvin tai että missä kipu tarkalleen sijaitsee.
- Sensorista tuntoaluetta/edustusalueiden herkkyyttä voidaan testata 2 pisteen erottelukyky testillä



Homunculus

2 pisteen erottelukyky testi

Aivojen uudelleen koulutus



- Hahmotuskyky on onneksi plastinen (joustava)→ sitä voidaan parantaa esimerkiksi harjoittamalla kehonkuvaa
- GRAPHESTHESIA- Harjoitteet perustuvat iholle piirrettyjen kuvioiden tunnistamiseen.
- Graphestesia harjoitteilla pyritään korjaamaan kroonistuneen kivun aivoille aiheuttamaa hahmotuskyvyn häiriötä ja sitä kautta vähentämään aivojen herkistymistä kivulle.
- Alustavia tutkimuksia aiheesta on julkaistu ja tulokset ovat olleet rohkaisevia
- Functionaalinen toiminnallinen aivojen kuvantaminen (MRI) on ollut apuna

Graphesthesia

Graphesthesia kotiharjoitteet

Graphesthesia harjoitteita tulee tehdä yhteensä 20 minuuttia päivässä. Tämä voidaan jakaa kahteen 10 minuutin kertaan, että harjoitteet vaativat keskittymistä.

Ohjeet:

1. Asetu vatsamakuulle.
2. Sulje silmät ja yritä rentoutua.
3. Avustava henkilö piirtää sormellaan alaselkään kirjaimia yksi kirjain kerrallaan.
   - Kirjainta ei tule piirtää selkärangan päälle.
4. Keskity tarkkaan kosketukseen ja sano ääneen kirjain jonka tunsit kirjoitettavan selkääsi.
   - Jos kirjain on väärä, avustava henkilö kertoo oikean kirjaimen.
5. Jatkakaa harjoitteita 10 minuutin ajan.

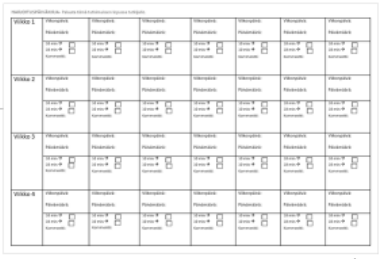
Kun harjoitteet alkavat sujumaan helposti, haastetta voi lisätä pienentämällä piirrettyjen kirjaimien kokoa tai muodostamalla 2-3 kirjaimen sanoja, kuten TIE, MOI, JÄÄ...

Ohjeet: 20 min päivässä → tämän voi jakaa 2 x 10 min

1. Asetu vatsamakuulle.
2. Sulje silmät ja yritä rentoutua.
3. Avustava henkilö piirtää sormellaan alaselkään kirjaimia yksi kirjain kerrallaan.
   Kirjainta ei tule piirtää selkärangan päälle.
4. Keskity tarkkaan kosketukseen ja sano ääneen kirjain jonka tunsit kirjoitettavan selkääsi.
   Jos kirjain on väärä, avustava henkilö kertoo oikean kirjaimen.
5. Jatkakaa harjoitteita 10 minuutin ajan.

Kun harjoitteet alkavat sujumaan helposti, haastetta voi lisätä pienentämällä piirrettyjen kirjaimien kokoa tai muodostamalla 2-3 kirjaimen sanoja, kuten TIE, MOI, JÄÄ...

Selkä tutkimus



Harjoituspäiväkirja

- Kyseessä 4 viikon pituinen tutkimus
- Graphesthesia hoitomenetelmä
- Lopputestaukset **16.11.2016** Selkäillassa

Graphesthesia

- Harjoitteet vaativat avustavan henkilön
- Harjoitteiden täytyy olla keskittyneesti ja tietoisesti tehtyjä
- 20 min päivässä → tämän voi jakaa 2 x 10 min
- Harjoituspäiväkirjan täyttäminen – Päivämäärä, 10min x 2 + kommentti

Kun harjoitteet alkavat sujumaan helposti, haastetta voi lisätä pienentämällä piirrettyjen kirjaimien kokoa tai muodostamalla 2-3 kirjaimen sanoja, kuten TIE, MOI, JÄÄ...

Muistakaa harjoituspäiväkirja ☺

GRAPHESTHESIA WRITTEN INSTRUCTIONS

Graphesthesia kotiharjoitteet

Graphesthesia harjoitteita tulee tehdä yhteensä 20 minuuttia päivässä. Tämä voidaan jakaa kahteen 10 minuutin kertaan, sillä harjoitteet vaativat keskittymistä.

Ohjeet:

1. **Asetu vatsamakuulle.**
2. **Sulje silmät ja yritä rentoutua.**
3. **Avustava henkilö piirtää sormellaan alaselkään kirjaimia yksi kirjain kerrallaan.**
   - **Kirjainta ei tule piirtää selkärangan päälle.**
4. **Keskity tarkkaan kosketukseen ja sano ääneen kirjain jonka tunsit kirjoitettavan selkääsi.**
   - **Jos kirjain on väärä, avustava henkilö kertoo oikean kirjaimen.**
5. **Jatkakaa harjoitteita 10 minuutin ajan.**

Kun harjoitteet rupeavat sujumaan helposti, haastetta voi lisätä pienentämällä piirrettyjen kirjaimien kokoa tai muodostamalla 2-3 kirjaimen sanoja, kuten TIE, MOI, JÄÄ...

Muista merkata harjoituspäiväkirja (harjoituslista) joka päivä!

APPENDIX I

CONSENT FORM REGARDING THE PARTICIPANTION OF THE EXPERIMENT

samk
Satakunnan ammattikorkeakoulu

Suostumus Selkätutkimusta varten

Olen saanut suullisesti ja kirjallisesti tietoa selkätutkimuksesta ja olen ymmärtänyt mitä tutkimuksessa tehdään.

Olen ymmärtänyt, että osallistumiseni selkätutkimukseen on vapaaehtoista ja että voin keskeyttää tutkimuksen milloin itse haluan.

_____
Paikkakunta

_____
Päivämäärä

_____
Allekirjoitus

_____
Nimenselvennys

_____
Osoite Syntymävuosi

_____
Tutkijan allekirjoitus

_____
Nimenselvennys

APPENDIX J

GRAPHESTHESIA TRAINING DIARY

HARJOITUSPÄIVÄKIRJA- Palauta tämä tutkimuksen lopussa tutkijalle.

Viikko 1	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:
	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:
Viikko 2	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:
	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:
Viikko 3	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:
	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:
Viikko 4 Lopputestaukset 16.11	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:	Viikonpäivä: Päivämäärä:
	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti:	10 min → ☐ 10 min → ☐ Kommentti: