AALBORG UNIVERSITY
STUDENT REPORT

The effect of short-term mindfulness focused attention meditation on pain sensitivity

2. Semester, Master Project - Spring 2018

Group 18gr8405

AALBORG UNIVERSITY
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School of Medicine and Health

Biomedical Engineering and Informatics

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The effect of short-term mindfulness focused attention meditation on pain sensitivity

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Synopsis

Studier har påvist, at langvarig mindfulness meditation kan forbedre en række kognitive funktioner for patienter med kroniske smerter. Imidlertid er antallet af studier, der undersøger effekten af kortvarig mindfulness meditation for patienter med kroniske nakkesmerter begrænset.
Formålet med dette studie er, at påvise om kortvarig mindfulness focused attention meditation kan påvirke smerte sensitivitet. Tryk smerte var påført på den højre øvre trapezius på raske forsøgspersoner med et algometer over to måling sessioner med 5 dages mellemrum. Herved blev smertetærsklen og smertetolerancen evalueret. Behandlingsgruppen udøvede 20 minutter mindfulness focused attention meditation over 5 sammenhængende dage, mens kontrolgruppen fortsatte deres normale rutiner mellem målingerne.
Resultater viser ingen signifikant forskel mellem behandlings- og kontrolgruppen. Yderligere er ingen signifikant ændring påvist i smertetærskelen og smertetolerancen. På trods af dette bidrager studiet stadig til området inden for smertelindring ved brug af mindfulness meditation.
Yderligere forskning er dog nødvendig for at undersøge effekten af mindfulness focused attention meditation over en længere periode eftersom, dette studie viser en tendens til at smertetærskelen og smertetolerancen øges.

Contents

1 | Introduction

Probably everybody experienced pain once, for instance due to a cut, burn or fall. The pain occurring right after an injury is called acute pain and disappears near-term. However, if the pain does not disappear the pain is looked upon as chronic pain. [1, 2]

Approximately 1.5 billion people, which equals 20% of the world population suffer from chronic pain [3, 4]. The characteristic of chronic pain is a duration more than three months [2]. Due to the persistence of pain the patients get restricted physically as well as psychically. The patients' ability to participate in diverse activities decreases. Those activities are not only physical but also social. For instance maintaining an independent lifestyle and relationships to friends and family can be affected. Besides the impacts on life, pain has impact on the work life. A survey in nine European countries [1] indicates that the persistence of pain had a lasting effect on their employment status for 25% of the patients. These patients changed their job, the job responsibilities or lost their job. Furthermore 21% of the employees were diagnosed with depression. [5]

25 % of the chronic pain patients in the UK suffer from neck pain [4]. Those patients are restricted by negatively affected fatigue and concentration [6]. Furthermore they suffer, like the majority of chronic pain patients, from anxiety and depressed mood, cognitive distress and the resulting physical limitations [7].

At the moment there is no cure for chronic pain patients. The current treatment methods only provide possibilities to relieve the pain. [8, 9] Nevertheless, the majority of the patients feels pain daily and this pain is increasing throughout the day due to daily activities [5]. Chronic pain is mainly treated by medication. However, those medicaments have side effects like abuse or organ damage. To avoid those risks, alternative methods are used. One of those methods is mindfulness meditation. Whereby meditation is used as mental training to achieve diminished judgment of emotions, cognitive control and existential insight. [10]

Previous studies show that mindfulness meditation provides the ability to enhance a broad spectrum of cognitive health outcomes. Furthermore stress, depression and anxiety can be relieved. This improvements are due to the mental training achieved by mindfulness meditation. Especially because of emotion regulation, cognitive control, acceptance and positive mood. [10, 3]

The present study addressed if mindfulness focused attention meditation can alter pain sensation in the neck by measuring pressure pain threshold and pressure pain tolerance before and after short-term mindfulness focused attention meditation. Therefore the hypothesis *"Short-term mindfulness focused attention meditation practice on 5 consecutive*

[1] FiXme Note: UK, France, Germany, Italy, Spain, Poland Sweden, Norway, Denmark

days increases the pressure pain threshold and pressure pain tolerance in the right upper trapezius" was tested.

2 | Background

2.1 Pain

Pain is defined, by the International Association for the Study of Pain, "as an unpleasant sensory and emotional experience associated with actual or potential tissue damage" [11]. Pain is a sudden or slow onset of any intensity from mild to severe pain [2] and can be categorized based on the pain experience as acute, chronic or intermittent pain [12]. In contrast to acute pain, chronic pain is is not anticipated or predictable. Chronic pain has a duration greater than three months with constant or recurring pain. Contrary to chronic pain, intermittent pain is not constant but has interruptions in between. [2]

Pain is a worldwide problem and affects all populations regardless of gender, age, income, ethnicity or geography. However, the distribution of chronic pain across the globe differs due to different risk factors such as female gender, injury and psychosocial environment [4]. The prevalence and incidence is high despite the complexity of quantifying pain. It is estimated that 20% of the adult world population suffer from pain and each year 10 % are diagnosed with chronic pain. [12]

The frequently causes of pain are trauma, surgery, cancer, arthritis, injuries and spinal cord problems. Furthermore, pain can lead to different conditions, such as depression, inability to work, limited social relationships and suicidal thoughts. [12, 5]

People with chronic pain often complain of cognitive problems, which interfere with their daily functions. Additionally, it is indicated that among people with chronic pain is a consistent evidence for disturbances in attentional capacity, processing speed, and psychomotor speed. However, the relationship between pain and cognitive problems is unknown. [13]

2.1.1 Types of pain

Pain can be divided into nociceptor pain and neuropathic pain [14]. Nociceptor pain can be classified according to the location of pain as somatic or visceral. Somatic pain occurs when nociceptors in the skin, muscles, skeleton, joints or connective tissues are activated. Visceral pain is defined as pain that results from the activation of nociceptors in the thoracic, pelvic or abdominal viscera. Unlike somatic pain, visceral pain is harder to localize within the body. [11]

Another type of pain is neuropathic pain, which is caused by a primary lesion or dysfunction of the peripheral nervous system or central nervous system. The main difference from nociceptor pain is that neuropathic pain has an absence of continuous nociceptive inputs. [11]

2.1.1.1 Nociceptor pain

Nociceptors are free nerve endings and have a high threshold for mechanical, chemical or thermal stimulation. There are two types of nociceptors, $\alpha\delta$ and C fibers. $A\delta$ fibers are myelinated nerve cells with a diameter between 2 and 5μm, which produce fast, well localized sharp pain. Those fibers are mostly distributed in the body surface, muscles and joints. C fibers are unmyelinated nerve cells with a diameter below 2μm, which produce slow and poorly localized burning and throbbing pain. The C fibers are distributed in most tissues. [14]

When a noxious stimulation occurs, the nociceptors will be activated and propagate the pain information to the spinal cord via the dorsal horn, which is illustrated as the red arrow in figure 2.1. The second order neuron is activated by the release of neurotransmitters from the nociceptor. The second order neuron receives these information and cross to the opposite side of the spinal cord and brings the information towards the brain via the lateral spinothalamic tract, which is indicated by the white arrow in figure 2.1. This information will be transmitted by releasing neurotransmitters to the third order neuron in the thalamus. The third order neuron localizes and discriminates the pain in the brain, illustrated as a black arrow in figure 2.1, but in the opposite side, in which the pain actually occurred. Perception of pain in the right side of the body is processed in the left side of the brain and vice versa. [15]

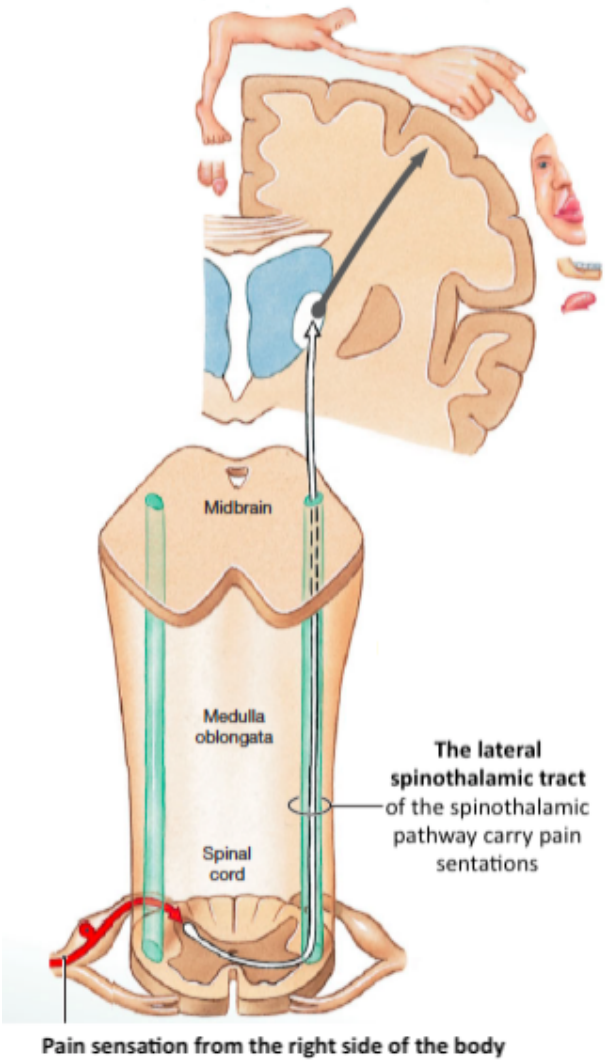

Figure 2.1: Spinothalamic pathway of nociceptor pain. The red arrow indicates the pathway of information from a noxious stimulus. The white arrow indicates the transmission of information towards the brain. The black arrow indicates the pain localization and discrimination in the brain. (Modified [15])

2.1.1.2 Neuropathic pain

Neuropathic pain is caused by a disorder in the somatosensory system and is often a chronic condition related to injuries or diseases. The disease occurs at different levels in the nervous system and affects the signaling of pain. Compared with nociceptor pain, it is difficult to localize the distribution of neuropathic pain. However, neuropathic pain can be described based on the mechanism and be divided into peripheral, central or mixed syndromes correspond to the anatomy and the underlying disease. This mechanism can produce painful symptoms in the same disease, but it would take different aspects. The

sensation can be described as sudden pain which is burning, tingling, shooting, stabbing or numb and can be intermittent or continuous. [16]

2.2 Assessment of Pain

Pain is described as a complex and subjective experience that poses a number of measurement challenges due to its subjective nature. Nevertheless, pain measurements are necessary for pain studies as well as the evaluation of methods to control pain. [17] Despite the challenges that pain measurement present, several tools and approaches can be employed in order to collect useful pain estimates [18]. The aim of pain assessment is to diagnose the cause, understand the impact, identify appropriate pain relief strategies and evaluate their effectiveness [1].

The intensity of pain can be assessed using unidimensional or multidimentional scales [17]. Chronic pain is too complex to assess with unidimensional scales, as the pain affect the patients' functions, quality of life, emotional state, vocational status, social life and well-being, wherefore multidimensional scales are used [19].

2.2.1 Unidimensional scales

One used unidimensional scale is the Verbal Rating Scale (VRS), which consists of a list of adjectives describing different levels of pain intensity, as illustrated in figure 2.2. This type of scale is easy to administer, score and apprehend. However, it has several statistical disadvantages and criticism raised due to the fact that it assumes equal intervals between the adjectives. [17] For this particular reason along with others, it is only used when the patient's conditions require it [20].

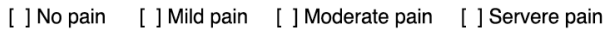

Figure 2.2: Verbal Rating Scale for pain assessment. (Modified [17])

Another possibility of unidimensional scales is a Visual Analogue Scale (VAS). VAS consists of a 10 cm line, as shown in figure 2.3. The ends of this line are labeled as the extremes of pain. The scale is scored by measuring the distance from 'no pain' to the patient's mark. This fact makes the VAS more sensitive to changes in pain intensity. However, one of the drawbacks is its evaluation time is higher than for other methods. [17]

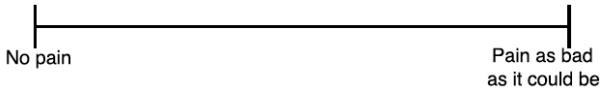

Figure 2.3: Visual analogue scale for pain assessment. (Modified [17])

Another method is the Numerical Rating Scale (NRS), which is illustrated in figure 2.4.

It is the most used by clinicians, due to the usefulness of administration and scoring. [21] NRS consists of a numerical scale from 0 to 10, describing 0 as 'no pain' and 10 as 'higest level of pain'. The advantage of NRS is that it does not require patients' mobility because the response is given verbally. NRS is a valid method and demonstrates positive and significant correlations with other measurements of pain intensity. [17]

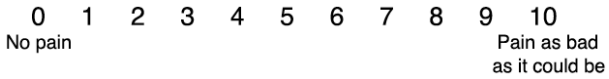

Figure 2.4: Numerical Rating Scale for pain assessment. (Modified [17])

Pictures or face scales can be used to illustrate facial expressions of different intensities of pain. The primary purpose of these scales is to offer individuals with written language or cognitive difficulties, an option to express pain intensity. There is evidence that the pictures or face scales are a valid method. [17]

2.2.2 Multidimensional scales

Multidimensional scales are convenient in relentless pain conditions. There are several multidimensional scales, whose purpose is to measure several dimensions of pain with different combinations of these dimensions. These scales offer a more detailed reflection of the patient's pain experience than unidimensional scales. [1]

The most frequently used is McGill Pain Questionnaire (MPQ), which consists of 78 words and describes the pain in sensory, affective and evaluative terms. These terms are arranged in groups according to the quality and intensity of pain. A 6-point VRS is used to determine the intensity of the pain. One disadvantage of the MPQ is the length and complexity, wherefore a brief form of this questionnaire has been introduced. The short-form MPQ consists of 15 different descriptors in sensory and affected terms. Each descriptor is rated on a 4-point VRS scale. [22]

Pain drawing is often used for estimating the location of pain and involves a front and back drawing of the human body. Another used method is the checklist, which is a simple list of possible sites of pain. [17]

2.2.3 Quantitative sensory testing

Quantitative Sensory Testing (QST) is a method to assess the patients' response to quantifiable sensory stimuli in order to characterize the location of pain. QST is used for assessing neuropathic pain and includes different modulations of stimulation, such as thermal, mechanical, electrical, ischemic and chemical. Approaches for QST used in clinical practice are the Frey monofilaments and tuning forks which are used to measure mechanical sensation. Heated or cooled metal rods can be used to assess thermal sensitivity. The

sensitivity of pressure pain can be assessed by an algometer. [21]

2.2.3.1 Assessment of Pain Threshold and Tolerance

As a result to a set of experimental noxious stimuli, it is possible to obtain different parameters such as pain threshold or tolerance. Threshold is defined as the stimulus that produces an arbitrary but defined level of performance. There is a distinction between absolute threshold and sensory threshold. Absolute threshold is the energy required to elicit response in the primary afferent while the sensory threshold, is the minimal energy necessary to reach perception. Due to the fact that the sensory threshold is higher than the absolute threshold, the sensory threshold is a convenient parameter which offers the transition point between non-painful and painful stimulus. [23] The three classical methods used for testing the perception in stimulus detection are the method of limits, method of adjustment and method of constant stimuli. [24]

- **Method of limits**: The magnitude of the stimulus is presented either in ascending or descending order by the examiner. The subject indicates whether or not the stimulus is detected. Accordingly, the threshold in each case is the stimulus magnitude at which the response switches from non-perception to perception and/or vice versa. [25]
- **Method of adjustment**: This method is a variant of the method of limits, whereby the magnitude of the stimulus is adjusted by the subject until the response switches from non-perception to perception and/or vice versa [25].
- **Method of constant stimuli**: The magnitude of the stimulus is randomly selected from a predefined set. It provides the most accurate estimates of the threshold, as the observer is not able to anticipate the next stimulus. The stimulus is presented in randome order and sometimes the choice of this stimuli set demands pilot work to obtain an estimate of the threshold. [25]

The pain tolerance is the highest intensity of painful stimulation that an individual is able to tolerate. There exist two different components of pain tolerance, firstly the nociceptors which send the information to the brain and secondly perception of the pain in the brain. At the moment the distinction between pain tolerance and stimulus tolerance is not clear in the literature. The stimulus tolerance is the pain elicit by the stimulus. The current research studies mainly focus on the stimulus tolerance, since it is diffucult to asses pain tolerance because it requires that pain intensity reaches tolerance levels for all subjects. [26] To obtain the stimulus tolerance value, either the intensity or duration of the stimulus is increased until the individual is not able to endure more pain [23]. Psychophysical research has been mostly focus on threshold measurements [27]. Pain tolerance is less used due to ethical reasons as well as its high variability among the subjects. Pain tolerance values are highly altered by psychological and psychosocial factors, however pain threshold values seem to be relatively less variable. [23]

2.3 Treatment of chronic pain

There are several treatment methods for chronic pain patients, depending on the modalities and intensity of the pain. Besides conservative methods, alternative methods are applied to reduce chronic pain. [8, 9]

None of the different treatment methods is enough or sufficient when applied alone. But an individual combination considering the needs of each patient alleviates suffering of chronic pain. At the moment it is not possible to cure chronic pain only to relieve the suffering. [8, 9]

The common used treatment method is medication. The disadvantage of medication is the risk of side effects. In contrast to medication, alternative methods do not provide negative side effect. However some of those methods require a specialist for instruction and/or application, which results in high costs. [8, 9]

2.3.1 Medication

Medication is a common way to treat severe chronic pain patients. Medicaments can be divided into three groups, the coanalgesic, non-opioid and opioid analgesics. [8]

- **Coanalgesics** are normally used to treat other diseases like depression, but still provide analgesic qualities. They are often used to treat fibromyalgia, chronic headache and neuropathic pain. Coanalgesics are frequencly combined with analgesics to extended pain-relief. [8]
- **Non-opioid analgesics** are used to reduce intermittent mild to moderate pain. To this category belong nonsteroidal anti-inflammatory drugs, which decrease inflammation and provide analgesic properties. Non-opioid analgesics are especially used in short-term-therapy. Non-opioid analgesics inhibit the prostaglandin synthesis. Prostaglandin has a protective effect to the organs. A permanent use of non-opioid analgesics encourages prostaglandin effects, which conduct in severe organ toxicity. Known side effects are for example gastrointestinal toxicity, nephrotoxicity and an increased risk of cardiovascular diseases. [8, 28]
- **Opioid analgesics** provide stronger analgesic qualities than non-opioid analgesics and show no prostaglandin effect. These analgesics work by bending in the central nervous system to the opioid or NMDA receptors. Because of better long-term tolerability, opioid analgesics are used in patients, who suffer from chronic non-malignant pain. However the use of opioid analgesics accompanies with the risk of abuse and misuse. Studies have shown that the median time until abusive behavior is 2 years. Treatment targets and specific requirements are set to minimize this risk. [8, 28] The decision, if non-opioid or opioid analgesics are used, is based on weighing

safety, tolerability and effectiveness. The superior effectiveness and the lower organ toxicity of opioid analgesic outweigh the risk of abuse or misuse. [8]

2.3.2 Physical therapy

Physical therapy is applied with the aim to enhance the patients' flexibility, general fitness and musculature. This is achieved by motion exercises and passive joint mobilization, which enhance the muscle function and the joint stability and mobility. A special program is adapted to the patients' needs. Components of this program might be moist heat, cryo therapy, ultrasound and transcutaneous electrical stimulation. Furthermore, assistance can be provided by manual therapy or exercise, which is included to improve the physical fitness, achieve weight loss and decrease the risk of chronic diseases encouraged by inactivity. [8, 9]

2.3.3 Lifestyle changes

Habits or life circumstances can intensify chronic pain. It is known that the pain sensitivity is negatively enhanced by nicotine. Therefore quit smoking can be a step towards relieving chronic pain. Furthermore, chronic pain patients often suffer from insomnia. Sleep hygiene should be applied to reduce the occurrences as well as the severity of the sleep disturbances. If insomnia is due to medication, it should be revised, if it is possible to change the medication. Obesity is a risk factor in the likelihood to develop chronic pain, this is encouraged by the side effects of obesity like psychological disability or musculoskeletal pain. Besides, it encourages other health problems for example cardiovascular disease or diabetes. To improve this condition, weight loss should be achieved by the combination of approperiate diet and exercise. This will influence the recovery abilities from pain positively. [8, 9]

2.3.4 Psychological therapy

Psychological therapies have been promoted due to their potential effectiveness for the management of chronic pain and its consequences [29]. Psychological treatments are characterized as cognitive or behavioral strategies, whose purpose is to helps patients to reduce depression or anxiety and enhance a positive attitude [30]. It assists patients to identify necessary lifestyle changes and implement them. [8, 9]. The most popular treatment program is Cognitive Behavior Therapy (CBT). The patients learn that their chronic pain condition has no cure but can be managed using different skills such as relaxation training, environmental changes or behavioral experiments. [31] It has been shown that CBT can reduce pain right after a treatment, however the effect is slight [30]. Psychological trauma, victimization or serious emotional and relational conflict are not addressed on CBT, which is one of the limitations [31].

2.3.5 Surgery

Surgery is a less frequent treatment technique. Commonly it is used to relieve patients from pain due to anatomic abnormalities. [8, 9] In some cases surgery is not recommended, hence risks and benefits of surgery should be considered. In addition, surgery is one of the most frequently cases of getting chronic pain, as mentioned in section 2.1. Therefore, it should be weighted if it is better to harked back to other less invasive treatment options. [9]

2.3.6 Acupuncture

Acupuncture is a treatment method whereby small sterile needles are inserted into the skin of the patient. The needles are inserted at specific acupuncture points related to the type of pain the patient is experiencing. [32] A study by Junnila [33] showed promising results in acupuncture reducing pain with soft tissue around the shoulder joint, headaches, neck and shoulder pain, arthritis and low back pain. Furtermore it was shown that the effect of acupuncture can last for more than 3 months in 80 % of the patients. [33]

2.3.7 Chiropractor

Chiropractic treatment is adjustment and manipulation of the spine to align the vertebrae to reduce pressure on the nerves running down the spine [34]. In some cases this therapy will increase flexibility of the spine of the patient and relieve the pain after a few treatments [35].

2.3.8 Hypnosis

Hypnosis is a guided process which can be carried out alone or by others. Thereby one come into the state of trance and feels deep relaxation and is open to conversation verbally. [34] Factors as anxiety, depression and other states of mood, as well as in general the social life of the patient has been shown to play a role in chronic pain. These mechanisms might be altered by hypnosis. In the literature hypnosis has shown positive results in pain relief, but only on a short term basis. [32] One of the drawbacks of hypnosis is the lack of standardization in hypnotic induction and interventions [36]. Furtermore the hypnosis susceptibility varies from person to person, wherefore not everyone will have the same effect from it [37].

2.3.9 Yoga

Yoga is a form of mind to body originating from India. In the practice of yoga different physical postures and breathing techniques are the routine. Yoga is a form of personal evolution, but most popular because of the exercise which benefits the health. [38] A review by Whitehead et al. [38] found that yoga could improve the functionality of the

back and a slight effect of treating pain compared to non-yoga participants.

2.3.10 Meditation

Meditation can be described as the intentional self-regulation of attention from moment to moment [39]. The term meditation encompasses a variety of mental-training practice, which depend on the mental activity promoted, the amount of training recommended, the use and qualifications of an instructor, and the degree of emphasis on religion or spirituality. There are some meditative techniques integrated into an alternative approach such as dietary or yoga. [40] Meditation practice can be divided into two main classes, concentration meditation and awareness meditation. While the concentration methods restrict the attention to a point, an object, the breath or a mantra [39], awareness meditation is the practice of being aware in the present moment [3]. The practice presupposes concentration to maintain steady attention instead of restricting attention to one object [39]. Awareness meditation practice is said to have several health benefits like increase in cognitive function and decrease in stress, depression and anxiety. Through some of these mechanisms pain can be altered, eventually leading in pain relief. [3]

2.4 Mindfulness

Mindfulness has its roots in Buddhism and yogic tradition and is described as a non-elaborative and non-judgmental awareness of the present moment [3, 39, 10, 41]. Within a mindfulness stage one is focusing from one moment to the other and is aware of emotional, cognitive and sensory events. Those events are perceived as temporary, fading and changeable. Moreover one is neither rating nor reacting cognitive or emotional to those events. The mental state of mindfulness can be achieved by mental training. [3, 10] Thus it can be said that mindfulness meditation is training of the mind [41].

Since thoughts and emotions are involved in the perception of pain, mindfulness provides the ability to relieve pain. Mindfulness cannot cure pain, but the patients will be able to accept the pain and reduce the fear associated with pain. Thereby the patients engage more in their treatment instead of relying and focusing on the effects of medication. [42] Often used methods to reach mindfulness are meditation and yoga practice [39]. Mindfulness meditation is not affected by physical limitation and no prior knowlegde is needed [41].

2.4.1 Meditation classification

The most well practiced types of meditation are focused attention (FA) and open monitoring (OM) [3]. FA is the training of concentration. The subjects keep their focus at an object or specific thing. Hereby the flow of breath is often used. If any disturbance comes by, like a thought, sound or other environmental distractions, the person should always bring the attention back to the focus. [3] OM is the cultivation of open presence. The

mind is open to anything, not focusing on any specific thing, just being in the present. If any thought or disturbance comes by, the thought or sensation should be noticed briefly, but then left without thinking about it. FA is used to slide into OM, therefore it is necessary to master FA before one can reach OM. [43, 3, 39]

2.4.2 Mechanisms of mindfulness

Previous research indicates that mindfulness meditation is promising for pain relief, even though the research is limited, and the mechanisms behind mindfulness meditation are not fully understood yet [43]. Studies show that enhanced emotion regulation, cognitive control, acceptance and positive mood have been linked with health benefits as well as pain modulation. These mechanisms are modulated during mindfulness meditation practice. [3, 10, 41, 43, 44]

Through mindfulness meditation one is able to take the attention away from the emotional component of pain. Therefore meditation practice can reduce the brain process areas related to anticipation of pain, which does not imply that meditation reduce the brain process related with pain. [45] Pain as well as meditation alter sensory, cognitive and affective dimensions of subjective experience. Therefore brain areas activated during meditation and nociception should be interconnected in a way. [44]

A study by Perlman et al. [43] and Zeidan et al. [10] show that practicing meditation could not lower the intensity of pain, but instead lower the pain unpleasantness in the participants. Similarly, a study by Brown et al. [45] showed that the greater the meditation experience, the lower the perception of pain unpleasantness. This results in lower activation of the right Inferior Parietal Cortex (IPC) and Midcingulate Cortex (MCC). [45] These findings are supported by a study by Lutz et al. [46], which shows that unpleasantness rating of pain decreases with meditation experience.

A study by Gard et al. [47] reported that the brain pattern related with pain modulation during mindfulness differs to other pain coping strategies. An increased activation in the rostral Anterior Cingulate Cortex (ACC) and the ventromedial Prefrontal Cortex (PFC) in the anticipation of pain stage was found for mindfulness practitioners. The activation of this areas has been identified with positive emotions. [47] Furthermore, the study by Gard et al. [47] found for mindfulness practitioners an increased activation in the rostral ACC and ventromedial PFC while anticipating pain, as well as decreased activation in the bilateral lateral PFC and increased activation in the posterior insula and secondary Somatosensory cortex (S2) when receiving a stimuli. Moreover, a study by Grant et al. [48] showed that mindfulness practitioners have different neuronal responses to painful stimuli with a greater activation in the insula and thalamus and a decrease activity in PFC.

The most involved brain regions in pain modulation via mindfulness meditation are the PFC and the ACC as illustrated in figure 2.5. Furthermore striatum, insula and Default

Mode Network (DMN), which includes the medial PFC and the Posterior Cingulate Cortex (PCC) are shown in figure 2.5. These regions play a big role in the effect of mindfulness meditation and are highly regulating the mechanisms of meditation, which can generally be divided into three categories: Attention control, emotion regulation and self-awareness. [1]

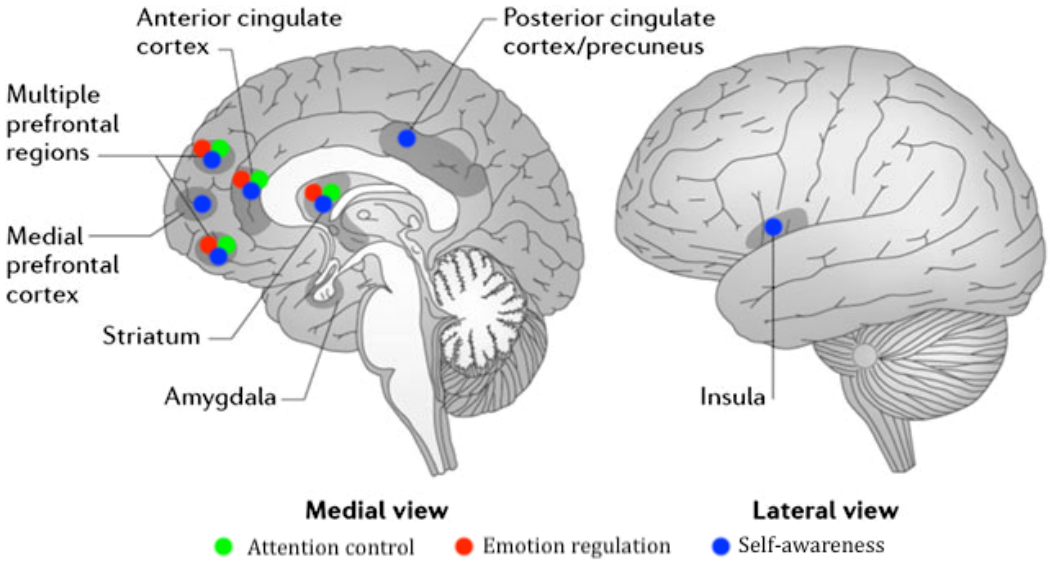

Figure 2.5: Specific regions in the brain altered by mindfulness meditation practice. Brain regions involved in attention control are shown with green, emotion regulation with red and self-awareness with blue dots. (Modified [41])

- **Attention control** is the ability to maintain focus, for instance on the breath during FA meditation. This mechanism includes mainly ACC, PFC and the striatum, which are illustrated in figure 2.5 as red dots. Increased activity in the dorsal lateral PFC is required to hold an increased attention, as well as deactivation of the areas of the brain that makes the mind drift, which include the medial PFC. [41]

- **Emotion regulation** includes experience and expression of arising emotions. This mechanism involves multiple prefrontal regions, limbic regions and striatum, which are regions primary regulating the emotional thoughts through the limbic system also responsible for goal setting. These regions are illustrated as green dots in figure 2.5. Emotional control is important because the participant needs to be able to handle boredom or negative mood during the meditation. Stronger subgenual and adjacent ventral ACC activity is present with meditation. Furthermore the dorsal lateral PFC and amygdala are involved in regulation of emotion. [41]

- **Self-awareness** means the awareness of oneself, being conscious and the internal bodily state. The involved regions of the brain are midline cortical structure DMN, ACC, the insula, medial PFC and PCC, as illustrated in figure 2.5 as blue dots.

[1] FiXme Note: do we need citations here?

Reduced activity in midline cortical structure including the DMN, more reduction in the posterior part PCC, than the anterior part medial PFC, but increased in perigenual ACC activity is found. [41]

2.4.3 Stages of meditation

Different expertise of meditation appears to modulate the dynamic balance between anterior and posterior midline networks involved in different aspects of self. This reflects self-plasticity following meditation. The effort to get into the meditative state varies according to your experience level with meditation. Often this experience level can be divided into three stages: Early, middle and advanced practice of meditation. These stages, illustrated in figure 2.6, determine the amount of effort to get into the meditative state. [41]

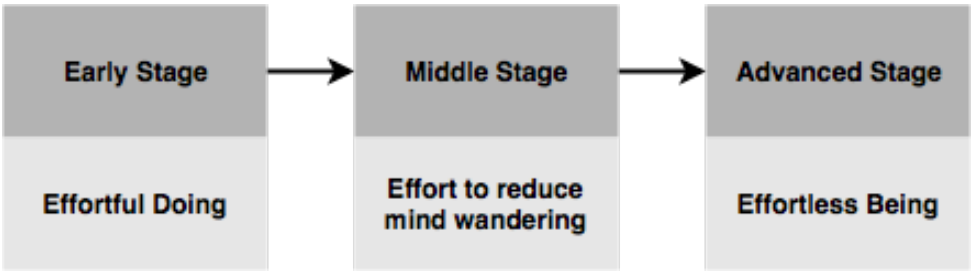

Figure 2.6: Stages of meditation practice, early, middle and advanced stage (dark grey), and the necessary effort to get and stay in the meditative state (light grey). (Modified [41])

In the early stage more mental effort is required. Hereby the dorsal lateral PFC and partial cortex are often involved and activated more. A stronger deactivation in the DMN occurs when more effort is used. With less effort, the ACC and striatum will participate more. [41]

2.5 State of the Art

Chronic pain has been investigated for years in order to understand the mechanisms behind and the topic is still relevant to explore as many people suffer from chronic pain. Furthermore, it is an issue that pain is difficult to treat due to the individually experience of pain and the subjective assessment of pain. [1, 49]

Currently there is no cure for chronic pain, only relief treatment methods. The primary treatment method is pharmaceutical, which has possible side effects, such as abuse or toxicity. Alternative treatment methods like physical therapy, chiropractic and acupuncture have shown an impact in relieving pain. But these treatment methods are most likely used in combination with pharmaceutical treatments. Many alternative treatment methods have disadvantages such as high costs, wherefore the decision for these treatment

methods should carefully be considered, to ensure that it suits the patients' needs and to maximize the effect for the cost. [8, 9]

Mindfulness meditation has proved to relieve conditions such as stress, depression and anxiety through the ability to enhance emotion regulation, cognitive control, acceptance and positive mood [3, 10]. Studies have investigated the usefulness of mindfulness meditation for people with chronic pain showing promising results in pain relief [39, 50].

The most common used mindfulness-based intervention is MBSR [51], which consists of 8 or 10 weeks of mindfulness meditation whereby the patient has to attend once a week a course for 2 hours and 45 minutes session at home 6 days per week [39, 52]. Patients suffering from chronic pain improved pain symptoms as well as life quality after the finalization of MBSR [10]. Hence, MBSR provides significant improvement for patients suffering from neck pain [50].

Even though long-term mindfulness meditation is the most investigated, short-term mindfulness training has also shown relief of pain. The studies have investigated different duration of meditation practice and time period within short-term mindfulness meditation. Consequently the boundaries of short-term mindfulness meditation are not well defined. A study by Ussher et.al. [53] showed in a clinical setting that 10 minutes mindfulness-based body scan reduces distress and the perception of pains' impact on daily living. However, the study found no effect outside the clinical environment [53]. Another study by Zeidan et.al. [10] proved that only three days of mindfulness meditation with a 20 minutes session each day have an effect on relieving chronic pain.

Some studies have studied the effect of mindfulness meditation for musculoskeletal chronic pain unifying lower and upper back pain, shoulder and cervical pain [52]. Nevertheless, there is not much literature available focusing on chronic neck pain. The most investigated method is MBSR, mostly over a time period of two months or more. A shorter time period of mindfulness meditation has not been investigated focusing on neck pain.

3 | Problem formulation

Pain levels of chronic pain patients are difficult to assess and quantify. Chronic pain patients experience a habituation effect to the pain. Additionally there are variations of the pain sensitivity between days and throughout the day which makes it difficult to get reliable and comparable pain levels of these patients. Since chronic pain is a subjective and multidimensional experience, another way to get comparable values of pain was chosen. Therefore pressure pain was applied with an algometer on healthy subjects. The application of pressure with an algometer was chosen to assess pain, because pressure satisfies the requirements of an suitable method for the quantification of pain [54]. Hence pressure pain threshold (Threshold) and pressure pain tolerance (Tolerance) values were used to test the following hypothesis: *Short-term mindfulness focused attention meditation practice on 5 consecutive days increases the pressure pain threshold and pressure pain tolerance in the right upper trapezius.* In this study meditation was used, because physical limitations are not affecting the meditation practice and no prior knowledge is needed [41]. In mindfulness meditation FA is used to slide into OM, therefore it is necessary to master FA before one can reach OM [43, 3, 39]. Hence the chosen meditation technique in this study is FA. The upper trapezius was chosen for the pressure application, because it is involved in chronic neck pain and has the lowest Threshold values compared with other muscles [55, 56]. Even though the study was conducted in healthy subjects, the sensation of the pain and the effects of meditation to the pain sensitivity can be transferred to chronic pain patients [57].

4 | Methods

4.1 Subjects

42 healthy subjects were recruited for the experiment, 21 males and 21 females, with a mean age of 23.93 ± 2.74 years. To get a homogeneous group of participants, specific inclusion and exclusion criteria were formed for this experiment.

Inclusion criteria:

- Age between 20 and 35 years
- No obesity
- Time to meditate for 5 days, 20 minutes per day

Exclusion criteria:

- Ongoing meditation practice
- Acute or chronic pain
- Pregnancy
- Neurological, musculoskeletal or mental illness
- Drug or alcohol abuse
- Medication with antidepressant or analgesic properties
- Lack of ability to cooperate

4.2 Study design

The subjects, recruited for the experiment, were assigned into different groups, treatment and control group. Whereby an equal gender distribution was strove. The treatment group was measured before and after the intervention, which was the practice of mindfulness FA meditation. To ensure that a detected effect was not due to habituation to the measurements, a control group was measured with the same time difference in between. Moreover, to minimize bias, the examiner was blinded. The structure of the study design is illustrated in figure 4.1.

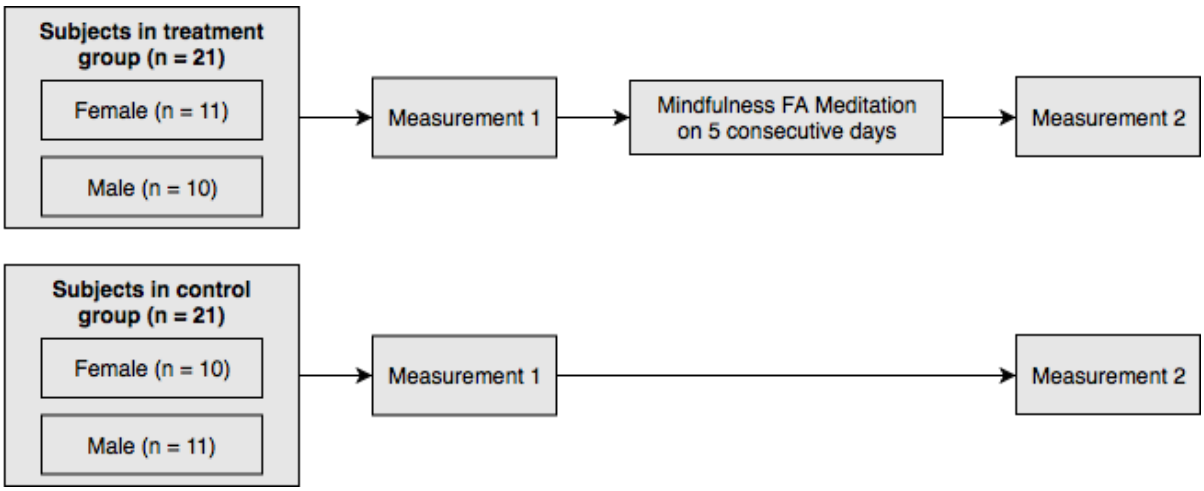

Figure 4.1: Parallel study design, whereby subjects were assigned into treatment and control group striving an equal gender distribution. The treatment group was meditating on 5 consecutive days between the measurements, whilst the control group continued their normal routine.

4.3 Procedure

Firstly general information about the subjects were collected, which are illustrated in table A.1 and table A.2 in Appendix A. Furthermore, information about the experimental procedure was given to the subjects. The measurement point was marked at the right upper trapezius, as illustrated in figure 4.2, while the subject laid prone, to ensure reliable and rapid location during the experimental procedure. The location on the right upper trapezius was determined by the midpoint between the acromion and 7th cervical vertebra. The distance was notated, so the same location could be used for each measurement session.

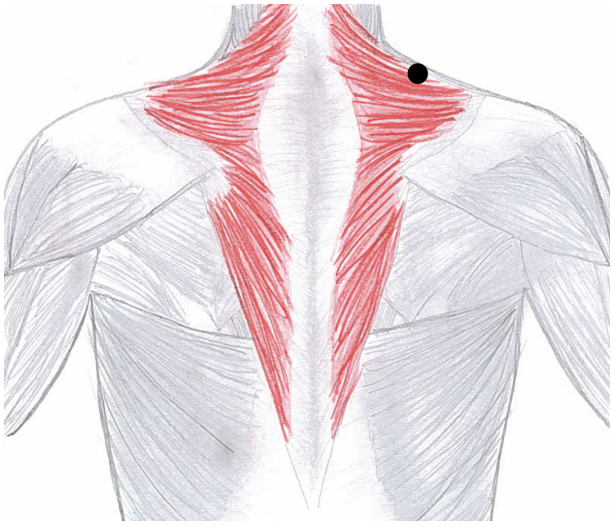

Figure 4.2: The measurement point on the right upper trapezius is marked with a black dot.

Threshold and Tolerance were measured with an algometer (Wagner Force Ten ™ Digital force Gage). During the use of the algometer it was considered that the pressure application should be conducted steady and consistent [56, 58], wherefore the examiner underwent a brief training with the algometer before the beginning of the experiment [58, 59].

Firstly, Threshold was measured, therefore the algometer was applied until the subject begins to feel the first sign of pain or discomfort. Secondly, Tolerance was measured at the same point and the pressure was applied until the maximum level of pain that the subject could stand was reached. Those measurements rely on the ability of the subjects to rate their own pain, hence the measurements were repeated three times to get representative values of Threshold and Tolerance. The average of these measurements was used for Threshold and Tolerance. To avoid hyperesthesia, there was 5 minutes pause in between the repetitions.

To test the effect of mindfulness FA meditation on Threshold and Tolerance, the treatment group practiced 20 minutes mindfulness FA meditation on 5 consecutive days. To ensure the same meditation conditions for all of the subjects, a guided meditation in form of an audio file was used. The used audio file was created as a combination of a recording of a guided mindfulness FA meditation [60] and Buddhist meditation music for positive energy [61]. The Buddhist meditation music is playing in the background consistently. From time to time guidance through the mindfulness FA meditation is provided by a male voice, which explains in the beginning to focus the attention on the sensations of breathing and reminds the subjects from time to time to bring the focus back to the breath. The complete content of the used audio file can be seen in Appendix B.

In the beginning of each meditation session subjects were told to have the most comfortable position during the meditation. Additionally a short introduction to mindfulness FA meditation was provided orally on the first day.

The subjects of the control group continued their normal routine. After the last meditation session of the treatment group the second measurement session was conducted. The same time interval between the measurements were used for the subjects of the control group. The second measurement session was conducted likewise the first measurement session.

4.4 Data Analysis

First a Shapiro-Wilk test was applied to evaluate the normality of the samples. Thereby the sample scores are compared with the scores, which are anticipated under normal distribution. The Shapiro-Wilk test has shown to be valid even in small samples ($n < 20$), wherefore it was chosen for this study. [62, 63] Afterwards a Levene's test was applied to evaluate the equality of variances.

According to the outcome of the Shapiro-Wilk test and the Levene's test, the parametric

tests ANOVA and t-test were chosen. The two-way mixed ANOVA was used in this study, whereby factor 1 denotes the group of subjects, either treatment or control group, and factor 2 denotes the measurement session, either the first (Pre) or the second (Post). Therewith it was evaluated, if there is a statistical significant difference between those data samples, i.e. two kinds of variations were evaluated, the between-subjects variation in factor 1 and the within-subjects variation in factor 2. Threshold and Tolerance have been analyzed with separate two-way mixed ANOVAs. [63]

The t-test was used to compare the changes in Threshold and Tolerance between the measurement sessions of both, treatment and control group. Therefore the difference relative to Pre measurement (relative difference) in Threshold and Tolerance between the Pre and Post measurement was calculated for each subject. A t-test was applied to test the mean difference between treatment and control group's relative difference [63]. The relative difference of Threshold and Tolerance have been tested separately.

5 | Results

The Tolerance of some subjects is not representative, as the examiner was not able to apply enough force with the algometer to reach the subjects' Tolerance. These subjects have been excluded. Therefore, the results are based on 32 subjects, 15 subjects in the treatment and 17 subjects in the control group.

5.1 Relative difference in Threshold and Tolerance

The mean of the three repetitions of Threshold and Tolerance measurements in each measurement session, Pre and Post, for the treatment and control group with associated standard deviation is illustrated in table 5.1 and table 5.2 respectively.

Table 5.1: Threshold and Tolerance, Pre and Post, as well as relative difference (rd) between these values with associated standard deviation for the treatment group. The mean of those values is indicated in the last row. Inconsistent numbering is due to exclusion of subjects.

	Threshold			**Tolerance**		
	Pre [kgF]	Post [kgF]	rd [%]	Pre [kgF]	Post [kgF]	rd [%]
#T1	1.84 ± 0.18	1.53 ± 0.30	-17.03	4.21 ± 0.25	3.93 ± 0.74	-6.66
#T2	2.95 ± 1.02	2.85 ± 0.06	-3.50	7.63 ± 1.06	5.70 ± 0.87	-25.26
#T3	2.13 ± 0.51	3.07 ± 0.29	43.75	7.75 ± 0.52	8.13 ± 0.52	4.99
#T4	0.94 ± 0.15	2.34 ± 0.10	148.94	3.85 ± 1.57	4.95 ± 0.24	28.55
#T5	1.35 ± 0.11	1.71 ± 0.35	26.11	3.11 ± 0.21	3.94 ± 0.47	26.55
#T6	0.31 ± 0.03	0.94 ± 0.18	206.52	5.95 ± 1.80	5.99 ± 1.02	0.67
#T7	2.07 ± 0.53	2.74 ± 0.41	32.15	5.44 ± 0.79	8.82 ± 0.82	62.13
#T8	1.82 ± 0.61	3.59 ± 0.38	97.44	7.21 ± 1.69	10.11 ± 0.61	40.11
#T9	2.17 ± 0.73	2.84 ± 0.50	31.08	6.98 ± 0.35	9.62 ± 0.60	37.82
#T11	2.22 ± 0.33	4.31 ± 0.97	93.99	4.45 ± 0.15	7.76 ± 0.51	74.25
#T12	1.99 ± 0.36	2.51 ± 0.37	26.51	4.45 ± 0.91	4.79 ± 1.07	7.49
#T13	1.14 ± 0.38	2.37 ± 0.52	108.19	4.48 ± 0.20	6.57 ± 1.13	46.58
#T14	1.69 ± 0.46	1.01 ± 0.04	-40.55	6.04 ± 0.98	3.93 ± 0.70	-34.88
#T19	1.77 ± 0.04	2.10 ± 0.49	18.42	9.66 ± 2.40	10.91 ± 1.04	12.87
#T21	3.91 ± 0.80	3.82 ± 0.45	-2.22	7.18 ± 0.72	10.58 ± 0.89	47.35

Mean:	1.89 ± 0.84	2.51 ± 0.97	51.32	5.89 ± 1.82	7.05 ± 2.53	21.50

Table 5.2: Threshold and Tolerance, Pre and Post, as well as relative difference (rd) between these values with associated standard deviation for the control group. The mean of those values is indicated in the last row. Inconsistent numbering is due to exclusion of subjects.

	Threshold			**Tolerance**		
	Pre [kgF]	Post [kgF]	rd [%]	Pre [kgF]	Post [kgF]	rd [%]
#C1	3.04 ± 0.34	5.00 ± 0.80	64.47	7.80 ± 0.32	12.07 ± 0.53	54.79
#C2	1.85 ± 0.29	2.27 ± 0.50	22.30	7.35 ± 1.07	9.45 ± 0.35	28.68
#C3	1.92 ± 0.18	1.81 ± 0.33	-5.90	4.90 ± 1.11	4.32 ± 0.18	-11.84
#C4	1.93 ± 0.06	2.09 ± 0.49	7.93	6.25 ± 1.19	7.31 ± 1.35	16.97
#C7	3.60 ± 0.83	4.34 ± 0.86	20.56	6.57 ± 0.36	8.96 ± 1.37	36.31
#C8	1.98 ± 0.54	2.57 ± 0.32	29.97	10.25 ± 0.48	10.91 ± 1.29	6.37
#C9	2.59 ± 0.42	3.19 ± 0.55	7.90	8.89 ± 1.74	9.51 ± 1.11	6.90
#C11	1.27 ± 0.22	1.29 ± 0.12	1.58	3.56 ± 0.41	5.21 ± 1.09	46.25
#C12	2.31 ± 0.39	4.32 ± 1.50	87.28	9.45 ± 3.06	10.05 ± 0.72	6.28
#C13	4.47 ± 0.11	2.56 ± 0.08	-42.69	8.51 ± 6.03	9.67 ± 1.66	13.67
#C14	1.85 ± 0.22	3.07 ± 0.95	66.43	5.17 ± 0.14	7.00 ± 0.81	35.31
#C15	1.14 ± 0.09	1.98 ± 0.24	73.68	5.83 ± 0.72	5.17 ± 0.98	-11.43
#C16	2.05 ± 0.51	2.06 ± 0.04	0.32	8.21 ± 1.02	7.98 ± 0.76	-2.84
#C17	1.52 ± 0.64	1.81 ± 0.28	18.86	10.77 ± 2.17	6.91 ± 0.09	-35.79
#C18	1.98 ± 0.50	2.05 ± 0.44	3.70	4.26 ± 0.33	4.36 ± 0.32	2.35
#C20	2.41 ± 0.57	2.97 ± 0.46	23.27	7.80 ± 1.91	8.96 ± 0.58	14.87
#C21	3.83 ± 1.33	4.06 ± 0.17	5.91	11.65 ± 1.59	11.32 ± 0.89	-2.78
Mean:	2.36 ± 0.92	2.79 ± 1.07	22.68	7.48 ± 2.32	8.19 ± 2.42	12.00

The relative difference in Threshold and Tolerance with associated standard deviation is illustrated in table 5.3.

Table 5.3: Relative difference (rd) in Threshold and Tolerance with associated standard deviation for both, treatment and control group.

	Threshold rd [%]	Tolerance rd [%]
Treatment	51.32 ± 67.06	21.50 ± 31.12
Control	22.68 ± 33.19	12.00 ± 23.02

A bar plot of the relative difference is illustrated in figure 5.1. The bars show the increase in Threshold and Tolerance as a percentage for both, treatment and control group.

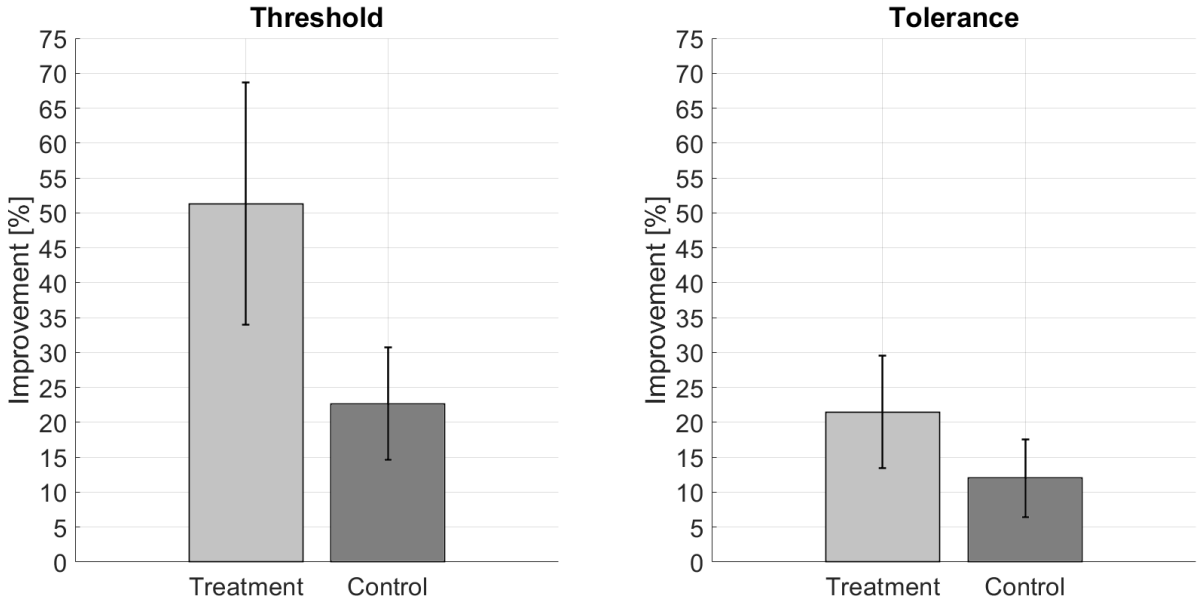

Figure 5.1: Relative difference for Threshold (left) and Tolerance (right) with associated standard error for treatment (light grey) and control group (dark grey).

5.2 Test of Normality

The results from the Shapiro-Wilk test ($\alpha > 0.05$), which was used to test for normality of Threshold and Tolerance, Pre and Post, for treatment and control group, are illustrated in table 5.4.

Table 5.4: Shapiro-Wilk test for normality of Threshold and Tolerance, Pre and Post, for treatment and control group. P-values marked with an asterisk indicate normality.

	Threshold Pre	Threshold Post	Tolerance Pre	Tolerance Post
Treatment	0.377*	0.930*	0.582*	0.142*

Control	0.077*	0.107*	0.976*	0.426*

The results from the Shapiro-Wilk test, which was used to test the normality of relative difference in Threshold and Tolerance, are illustrated in table 5.5.

Table 5.5: Shapiro-Wilk test for normality of relative difference (rd) in Threshold and Tolerance for treatment and control group. P-values marked with an asterisk indicate normality.

	Threshold rd	**Tolerance rd**
Treatment	0.197*	0.975*
Control	0.148*	0.929*

5.3 Test of Equality of Variance

The results from Levene's test ($\alpha > 0.05$), which was used to test the equality of variance of Threshold and Tolerance, Pre and Post, between treatment and control group, are illustrated in table 5.6.

Table 5.6: Levene's test for equality of variance of Threshold and Tolerance, Pre and Post, between treatment and control group. P-values marked with an asterisk indicate equal variance.

Threshold Pre	**Threshold Post**	**Tolerance Pre**	**Tolerance Post**
0.437*	0.551*	0.354*	0.658*

The results from the Levene's test, which was used to test the equality of variance of relative difference in Threshold and Tolerance between treatment and control group, are illustrated in table 5.7.

Table 5.7: Levene's test for equality of variance of relative difference (rd) in Threshold and Tolerance between treatment and control group. P-values marked with an asterisk indicate equal variance.

Threshold rd	**Tolerance rd**
0.013	0.159

5.4 Two-way mixed ANOVA

The dataset was normal distributed indicated in table 5.4, and had an equal variance indicated in table 5.6. Hence a two-way mixed ANOVA ($\alpha < 0.05$) was used to test if there is a difference within and between treatment and control group. Hereby the Pre and Post measurements of Threshold and Tolerance were compared to assess the within-subjects effect. Treatment and control group were compared to assess the between-subjects effect.

Results from the two-way mixed ANOVA are illustrated in table 5.8 for Threshold and table 5.9 for Tolerance.

Table 5.8: Two-way mixed ANOVA for Threshold, Pre and Post, comparing treatment and control group. P-values marked with an asterisk indicate significant difference. F-value and degree of freedom (df) are illustrated as well.

		df	F-value	p-value
Within-Subjects effect	Measurement	1	13.051	0.001*
	Measurement x Group	1	0.451	0.507
Between-Subjects effect	Group	30	1.492	0.231

The test indicates that there is a significant main effect between Pre and Post of Threshold measurements (within-subject effect, Measurement), $F(1,30) = 13.051$, $p = 0.001$. However, no significant main effect is seen between treatment and control group for Threshold (between-subjects effect, Group), $F(1,30) = 1.492$, $p = 0.231$ nor a significant main interaction between measurements and group (within-subjects effect, Measurement x Group), $F(1,30) = 0.451$, $p = 0.507$.

Table 5.9: Two-way mixed ANOVA for Tolerance, Pre and Post, comparing treatment and control group. P-values marked with an asterisk indicate significant difference. F-value and degree of freedom (df) are illustrated as well.

		df	F-value	p-value
Within-Subjects effect	Measurement	1	8.918	0.006*
	Measurement x Group	1	0.532	0.472
Between-Subjects effect	Group	30	3.289	0.080

The test indicates that there is a significant main effect between Pre and Post of Tolerance measurements (within-subject effect, Measurement), $F(1,30) = 8.981$, $p = 0.006$. However, no significant main effect is seen between treatment and control group for Threshold (between-subjects effect, Group), $F(1,30) = 3.289$, $p = 0.080$ nor a significant main interaction between measurements and group (within-subjects effect, Measurement x Group), $F(1,30) = 0.532$, $p = 0.472$.

5.5 T-test

A normal distribution indicated in table 5.5. Furthermore was an unequal variance seen for Threshold and an equal variance for Tolerance indicated in table 5.7, was seen for relative difference in Threshold and Tolerance for treatment and control group, thus a t-test ($\alpha < 0.05$) was used to test if there was a difference between treatment and control group. Results from this test are illustrated in table 5.10.

Table 5.10: T-test for Threshold and Tolerance relative difference for treatment and control group. P-values marked with an asterisk indicate significant difference. F-value and degree of freedom (df) are illustrated as well.

	df	F-value	p-value
Threshold	19.892	6.967	0.149
Tolerance	30	2.084	0.330

The test indicates that there is no significant difference in relative difference in Threshold, $F(1,19.892) = 6.967$, $p = 0.149$ and Tolerance, $F(1,30) = 2.084$, $p = 0.330$ between treatment and control group.

6 | Discussion

6.1 Summary and interpretation of the findings

A significant difference is found between Pre and Post measurement in treatment and control group, indicated by the two-way mixed ANOVA. This might be do to habituation to pressure pain. A study by Bingel et al. [64] showed, that healthy subjects habituate to pain over time. Furthermore a survey by Neddermeyer et al. [65] found that pain threshold does not depend on the source of the stimulus [1]. Hence the results show the habituation effect to pressure pain.

However, no significant difference in Threshold and Tolerance between treatment and control group is found. Furthermore, no significant difference in relative difference in Threshold and Tolerance is found between the groups, indicated by the t-test. Nevertheless a tendency can be seen that the treatment group has a higher relative difference in Threshold and Tolerance compared with the control group.

6.2 Experimental Setup

The pressure application with an algometer should be conducted steady and consistent [56, 58]. One of the drawbacks of the used algometer is the difficulty in accomplish this pressure rate, since the this algometer does not display a pressure rate. The examiner had difficulties to apply enough force to reach the Tolerance of some subjects. The outcome of the study could have been effected by the technique using the algometer and the examiner's fatigue after several measurements. According to Kinser et al. [58] and Vaughan et al. [59] it is important to train and practice with the algometer. However, due to the available time to execute the project, an appropriate training period was not possible, which would be convenient in order to achieve more representative values.

As mentioned in subsubsection 2.2.3.1, pain tolerance values are highly altered by psychological and psychosocial factors, while pain threshold values seem to be relatively less variable. Hence it appears convenient to only focus on the Threshold. This is not only because of the extensive variety within the measurement values, but also as it was not possible to reach a representative Tolerance of some subjects.

A study by Tesarz et al. [66] concludes that pain perception can be altered by physical activity. This could be seen in our study as subjects with good physical condition showed higher Threshold and Tolerance values compared with other subjects. Furthermore a study by Koltyn et al. [67] determines that high-intensity exercise is followed by hypoalgesia. Therefore Threshold and Tolerance values increase during and right after exercise [67]. On the other hand Serinken et al. [68] showed that Threshold is decreased

[1] FiXme Note: hot, cold, electric current, blunt pressure and punctate pressure

when applying pressure pain to sore muscles caused by physical exercise. Therefore the exclusion criteria should take into account that subjects cannot practice physical exercise right before or exorbitantly the days before a measurement session.

6.3 Meditation technique

There were some limitations within the used meditation technique. Potentially the used audio-guide did not ensure that the subjects understood the principles of mindfulness FA meditation, even though an oral introduction was given on the first day. However, this introduction was provided by a non-specialist, who possibly did not know the key focus of explaining mindfulness FA meditation to laymen. This uncertainty was based on the board spectrum of mindfulness meditation techniques and their unclear delineations. Furthermore, the subjects were told to meditate in the most comfortable position, which varied between the subjects. Inconsistent sitting positions may have influenced the meditation outcome of single subjects. In addition, there was no control if the subjects were meditating adequately.

Other studies have shown that mindfulness meditation has an effect on pain. Those studies investigated the effect of meditation practice over two months or more using MBSR. [39, 50] The effect on pain intensity and pain unpleasantness of short-term mindfulness meditation practice was shown by Zeidan et al. [10]. However, Zeidan et al. [10] used a meditation technique which combine FA and OM, particularly focusing on pain-related brain processing. Whereas this study was investigating the effect of short-term mindfulness FA meditation. Hence pain relief is affected not only by the type of meditation but also by the practice period. Therefore 5 consecutive days may not be sufficient to elicit mindfulness FA meditation's modulation of pain.

7 | Conclusion

Short-term mindfulness FA meditation on 5 consecutive days did not show a significant effect on pressure pain sensitivity in the right upper trapezius. However, a significant effect was found between Pre and Post measurement for treatment and control group, which was seen as an increase in Threshold and Tolerance. This increase between Pre and Post measurement indicates the habituation effect to pressure pain. On the behalf this a clear conclusion about the effect of short-term mindfulness FA meditation on pain sensitivity cannot be stated. Nevertheless this study provides insight into pain relief using mindfulness meditation as an alternative method. Since this study shows the tendency that 5 consecutive days of mindfulness FA meditation practice increase Threshold and Tolerance, a longer period should be investigated. Furthermore, a comparison of this and other studies indicates that the effect of mindfulness meditation varies depending on the meditation technique. Hence the effects of the different meditation techniques should be further investigated in order to evaluate if different meditation techniques provide various effects on pain relief.

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A | Subject information

Table A.1: Subject characteristics. Gender is indicated with either female (F) or male (F). The means and standard deviations are calculated for age and BMI.

Subject	Age	Gender	BMI
#T1	F	25	27.44
#T2	F	23	23.14
#T3	M	22	21.13
#T4	F	21	22.68
#T5	F	22	21.58
#T6	F	20	23.12
#T7	M	25	25.06
#T8	F	21	24.96
#T9	F	22	21.38
#T10	F	34	24.28
#T11	F	21	21.13
#T12	M	24	26.23
#T13	F	25	19.27
#T14	M	22	20.76
#T15	M	23	28.07
#T16	M	24	31.10
#T17	M	23	24.49
#T18	M	22	21.16
#T19	M	27	25.17
#T20	M	23	23.21
#T21	M	26	26.64
Mean	F(10) M(11)	23.57 ± 2.99	23.90 ± 2.90

Table A.2: Subject characteristics. Gender is indicated with either female (F) or male (M). The means and standard deviations are calculated for age and BMI.

Subject	Age	Gender	BMI
#C1	F	23	21.89
#C2	F	25	23.84
#C3	F	27	21.13
#C4	F	27	20.96
#C5	M	24	28.06
#C6	M	23	24.74
#C7	F	22	23.77
#C8	M	24	21.91
#C9	M	22	27.17
#C10	M	23	22.59
#C11	F	23	21.30
#C12	M	27	22.74
#C13	F	21	32.80
#C14	M	23	20.28
#C15	F	24	20.28
#C16	F	22	20.28
#C17	F	22	21.37
#C18	F	23	18.17
#C19	M	29	31.21
#C20	M	26	26.58
#C21	M	30	21.80
Mean	F(11) M(10)	24.29 ± 2.47	23.43 ± 3.67

B | Focused Attention Meditation

Title: Focused Attention Meditation ∼ Sensations of Breathing
Length of the whole tape: 22:40
Meditation time: 20 minutes and 1.5 minutes of introduction
Background music: Buddhist meditations music for positive energy
Speaker: David Noyce

During the whole recording calm music is playing in the background. From time to time the guidance through the meditation is provided by a male voice, which is illustrated in the text below in italics.

00:01 - 01:27: *Hello and welcome, this is a guided focused attention meditation in which will be focusing our attention on the sensations we can feel around our natural breathing process. Our breathing is something we can always feel natural happening, and focusing on it can help us to be fully present and to take a break from focusing on thinking. I will say a couple of things about this meditation, and then you will hear a bell ring three times to begin. Sometimes, as we are trying to focus on the sensation of breathing we might find our mind getting distracted, and this is a total natural part of meditation, it does not mean that we are doing it wrong, all we can do in those moments is notice that we have been come distracted and without judging our selves, remember our intention to focus on the sensation of breathing, no matter how many times our attention wonders, we learn to just notice and gently bring it back to the sensation of breathing, it might help to keep our focus somewhere in the body where we can feel the sensation of breathing clearly. So now let focus on our attention on the natural sensation of breathing. It might help us to start out with a few deep slow breaths, filling our lungs with air, and breathing out worries attention.*

01:28 - 01:36: Only background music

01:36 - 01:51: Three times sound of a gong

01:51 - 02:30: Only background music

02:31 - 02:46: *Whenever we notice our attention has wondered away from the breath we can just take a moment to be present with whatever our experience is, and then we can gently bring our focus back to the natural sensation of breathing.*

02:47 - 06:34: Only background music

06:34 - 06:42 *If you have notice that your attention is no longer present with the sensation of breathing, just take a moment to notice where it is, and then gently bring it back.*

06:43 - 11:35: Only background music

11:35 - 11:38 *Lets keep focusing on the sensation of our natural breathing.*

11:39 - 16:37: Only background music

16:38 - 16:45: *At some point we might be able to follow the whole cycle of sensations, all the way through the in-breath and all the way through the out-breath.*

16:46 - 19:35: Only background music

19:36 - 19:41: *We will meditate for another two minutes, so remember our attention to focus on the sensation of breathing.*

19:42 - 21:35: Only background music

21:35 - 21:45: Two times sound of a gong

21:45 - 22:40: Only background music