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Can mindfulness alter pain sensitivity?

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Synopsis

Preface

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1 | Introduction

2 | Background

2.1 Pain

This section will present the two types of pain, acute and chronic. Also the treatment of pain will be presented, both the most mused and alternative methods for treating and reliving pain.

2.1.1 Acute and chronic 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 [1]. Pain is a sudden or slow onset of any intensity from mild to severe pain [2] and can categorized based on the pain experience as acute, chronic and intermittent pain [3]. Acute pain is anticipated or predictable, while chronic pain is not anticipated or predictable. Chronic pain has a duration greater than three months with a constant or recurring of pain. Contrary to chonic pain, intermittent pain is not constant but have interruptions in between [2].

Pain is a worldwide problem and affects all populations regardless of gender, age, income, ethnicity or geography, but the distribution across the globe differs. The prevalence and incidence is high despite the complexity of quantifying pain. It is estimated that 20% of the world's populations adults suffer from pain and each year 10 % is diagnosed with chronic pain [3].

The frequently causes of pain are operations, cancer, osteoand rheumatoid arthritis, injuries and spinal cord problems. Furthermore, pain can causes to different sequelae, such as depression, inability to work, limit social relationships and suicidal thoughts. [3]

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 there is a consistent evidence for disturbances in attentional capacity, processing speed, and psychomotor speed. However, the relationship between pain and cognitive problems is unknown. [4]

2.1.2 Types of chronic pain

Lower back pain Knee pain neck pain

2.1.3 Nociceptive and neuropathic pain

Pain can be divided into nociceptor pain and neuropathic pain [5]. Nociceptor pain can be classify attending to the location of pain as somatic pain or visceral pain. Somatic pain occurs when nociceptors in 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. 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. [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 between 2 and 5μm and produce fast well localized sharp pain. The distribution of these fibers are in the body surface, muscles and joints. C fibers are unmyelinated nerve cells below 2μm and produce slow and poorly localized burning and throbbing pain. The distribution of C fibers are in most tissues. [5]

When a noxious stimulation occurs, the nociceptors will be activated and propagate the pain information to the spinal cord via dorsal horn, illustrated as the red arrow on figure 2.1 [6]. The second order neuron is activated by the release of neurotransmitters from the nociceptor. The second order neuron receive these information and cross over 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 write arrow. 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 on figure 2.1, but reverse from where the pain actually had occured. Perception of pain on the right side of the body is processed on the left side of the brain and vice versa [6].

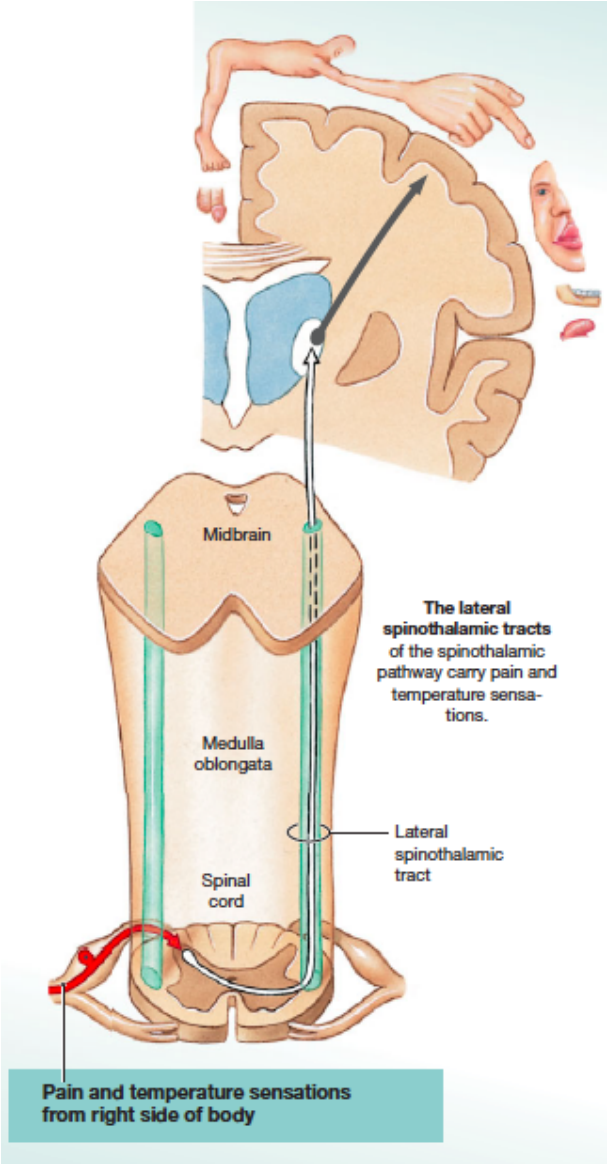

Figure 2.1: Spinothalamic pathway. Modified [6]

Pain is modulated by the descending pathways, where the Periaqueductal Grey (PAG) and the Nucleus Raphe Magnus (NRM) are involved in reducing pain. PAG, also known as anti-nociceptor, is important in the control of pain and surrounds the cerebral aqueduct in Mesencephalon. When this region is electrical stimulated it produces profound analgesia and injection of morphine. PAG receives inputs from the thalamus, hypothalamus, cortex and the spinothalamic tract. Neurons from the PAG region excite the cells in NRM which have a direction towards the spinal cord and block the pain transmission by the dorsal horn cells. Stimulation of NRM produce a strong analgesia and release serotonin which activates the inhibitory interneuron and blocks the pain transmission. The key neurotransmitter is noradrenaline and 5-hydroxytryptamine by modulation pain. [5]

Neuropathic pain

Neuropathic pain is caused by a disorder in the somatosensory system and is often a chronic condition related to injuries or diseases [7]. The disease occurs at different levels in the nervous system and affects the signaling of pain. It is difficult to localized the distribution of neuropathic pain compared with nociception pain, because the distribution is no longer respect by nerves, roots, segments, proximal or distal territories. However, neuropathic pain can be described based on a mechanism and be divided into peripheral, central or mixed syndromes correspond to the anatomy and the underlying disease. This mechanism can, however, produce painful symptoms in the same disease, but it would take different aspects. The sensation can be described as a sudden pain which is burning, tingling, shooting stabbing or numb and can be intermittent or continuous. Furtermore, pain can be divided into different types according to the evoked pain, which is illustrated in table **??**

2.1.4 Treatment of chronic pain

There are several ways of treatment for chronic pain patients, depending on the modalities and intensity of the pain. Besides conservative methods, alternative methods are applied to reduce chronic pain. The benefit of the alternative methods is a treatment without the risk of negative side-effects. [8, 9]

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

In the following chapters several treatment methods are described. On the one hand conservative methods like medication or surgery. On the other hand alternative methods like yoga, acupuncture, lifestyle changes or mindfulness meditation. But also other forms of therapy like physical and psychological therapy and chiropractic. Often it is not possible to mark out the individual treatment methods, because they intertwine with each other or are supported by each other.

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 to 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]

Psychological therapy

Psychological therapy helps patients to reduce depressions or anxiety and enhance a positive attitude. Also it assists patients to identify necessary lifestyle changes and implement them. [8, 9]

Lifestyle changes

Habits or life circumstances can intensify chronic pain. Changes of the lifestyle may help to decrease 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 to avoid medicine related insomnia. Obesity is a risk factor in the likelihood to develop chronic pain, besides, it encourages other health problems for example cardiovascular disease or diabetes. It is known that chronic pain occurs more often in people which are overweighted. This is encouraged by the side effects of obesity like psychological disability or musculoskeletal pain. To improve this condition, weight loss should be achieved by the combination of diet and exercises. This will influence the recovery abilities from pain positively. [8, 9]

Surgery

Surgery is a less frequent treatment technique. Commonly it is used to relieve patients from pain due to anatomic abnormalities. [8, 9] But also patients suffering from chronic low back pain can be treated by surgery. It is always necessary to weigh risk and benefits of surgery. Where appropriate it should be harked back to other and less invasive treatment options. [9]

Medication

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

- **Coanalgesics**
  Coanalgesics are normally used to treat other diseases, for example depressions, but still provide analgesic qualities. They are often used to treat fibromyalgia, chronic headache and neuropathic pain. Often coanalgesics are combined with analgesicts to extended pain-relief. [8]
- **Non-opioid analgesics**
  Non-opioid analgesics are used to reduce intermittent mild to moderate pain. To this category belong nonsteroidal anti-inflammatory drugs, which decrease inflammation and give analgesic properties. Non-opioid analgesics are especially used

in short-term-therapy. Non-opioid analgesics inhibit the prostaglandin synthesis. Prostaglandin has a protective effect. A permanent use of non-opioid analgesics encourages prostaglandin effects, which conduct in severe organ toxicity. Known side effects are for example gatrointestinal toxicity, pephrotoxicity and a increased risk of cardiovascular diseases. [8, 10]

- **Opioid analgesics**
  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 this better long-term tolerability opioid analgesics are used in patients which suffer from chronic non-malignant pain. But the use of opioid analgesics accompanies with the risk of abuse and misuse. Studies have shown, that the median time until abuse behavior is 24 months. Treatment targets and specific requirements are set to minimize this risk. [8, 10] 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]

Chiropractor

Chiropractic treatment is adjustment and manipulation of the spinal cord to alignment the vertebrae of the spine to reduce pressure on the nerves running down the spine. [11] In a study by [12] evaluating 506 patients with acute and chronic back pain after 3 month of chiropractic treatment. Patients undergoing chiropractic treatment showed improvements in their condition and the effect was ongoing after 3 month. [12]

Acupuncture

Acupuncture is a treatment where 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 that the patient is experiencing. [13] In a study by [14] acupuncture has shown promising results in reducing pain in patients with soft tissue round the shoulder joint, headaches, neck and shoulder pain, arthritis/osteoarthritis and low vack pain. A total of 348 patients where evaluated. The mean reduction of the entire patient group where 68 %. Showing best results in soft tissue round the shoulder joint, showin a mean reduction of pain by 79 %. The headache and neck and shoulder patients had a mean reduction by 74 %. Patients with arthritis/osteoarthritis showed a mean reduction by 58 % and the patients with low back pain had a mean reduction by 50 %. In 80 % of the patients the effect of the treatment lasted for more than 3 month and 32 % over one year. [14]

Hypnosis

Hypnosis is a process where the one comes into the state of trance and feels deep relaxation and is open to conversation verbally. Hypnosis is a guided process and can be carried out alone or by others. [11] Factors as anxiety, depression and other states of mood and the

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 to relieve pain, but only on a short term basis. [13]

Yoga

Yoga is a form of mind to body practice discipline, or tradition originating from India. In the practice of yoga different physical postures, breathing techniques and more are the routine. Yoga is both a form of personal evolution, but most popular because of the exercise which benefits the health. A review by [15] found that yoga could improve the functionality of the back and a slight effect of treating pain compared to non-yoga participants.

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2.1.5 Mindfulness meditation

Mindfulness is often defined as being in the mental state of non-elaborative, non-judgmental awareness [**Zeidan2012**, 16, 17]. Mindfulness is viewed upon as a lifestyle and the lifestyle of mindfulness can be practiced through meditation, called mindfulness meditation. Practicing mindfulness meditation includes control over sensory, emotional and cognitive happenings. Hereby the ability to control these sensations without being distracted by them as so the ability to abstract from past and future representations of memory. Hereby one can say that mindfulness meditation is training of the mind. [17]

Two popular practices of mindfulness meditation, focused attention (FA) and open monitoring (OM) are of the most well practiced types of meditation. [16]

Focused attention

FA is the training of concentration, where one keeps his or her focus at an object or specific thing, only focusing on that thing. Often the flow of breath is the focus, when practicing FA meditation. When any disturbance comes by, like a thought, sound or other environmental distractions, which will often lead to a drift in attention, the person should always bring his or her attention back to the focus. [16]

Open monitoring

OM is the cultivation of open presence, were 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 more over it. It is believed that this form of meditation is easier to learn when the person masters the meditation of FA, whereby the OM form is easier to master. [16]

Mechanisms of mindfulness meditation

Enhanced emotion regulation, cognitive control, acceptance and positive mood have been linked with health benefits as well as pain modulation. These mechanisms has been shown to be modulated during mindfulness meditation practice. A study by Perlman et al. [18] shows that practicing meditation could not lower the intensity of pain, but instead lower pain unpleasantness in the participants. [**Zeidan2012**, 18]

The typical response when using a placebo analgesia is increased activation of the dorsolateral prefrontal cortex during pain anticipation. Effect that predicts reductions in pain perception and activaty of pain related brain regions. Mindfulness meditation does not involve dorselateral prefrontal cortex activation. [**Zeidan2012**]

The findings on mindfulness meditation and pain modulation are split, but experiments in controlled settings are still needed to confirm if the effect of mindfulness meditation works on pain modulation. [**Zeidan2012**, 18]

Different brain regions are involved the practice of mindfulness meditation. The most important are the prefrontal cortex (PFC), involving the anterior cingulate cortex (ACC) and the medial PFC as illustrated in figure 2.2. The striatum, the insula and the default mode network (DMN), which include the medial PFC and the posterior cingulate cortex (PCC). These regions play a big role in the effect of mindfulness meditation and are highly regulating the mechnisms of meditation which can generally be catergorised into the three catagories, attention control, emotion regulation and self-awareness.

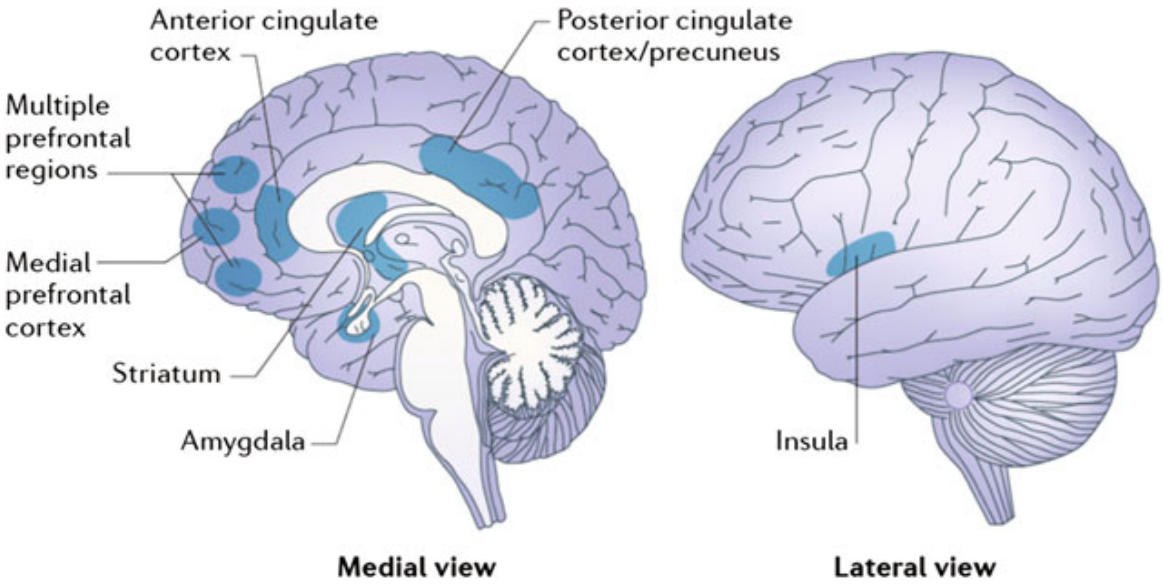

Figure 2.2: Image of the brain highlighting specific regions relevant when practicing meditation [17]

Attention control

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. Increased activity in the dorsal lateral PFC is required to hold an increased attention, aswell as deactivation of the areas of the brain that makes the mind drift, which include the medial PFC. [17].

Emotion regulation

Emotion regulation include the emotions that arise, when they occur and how they are experienced and expresed. This mechanism involves multiple prefrontal regions, limbic regions and striatum, which are regions primary in regulating the emotional thoughts through the limbic system also responsible for goal setting. This need for regulating the emotional control is important because during the meditation practice the participant must be able to handle bordom or negative mood during the meditation. Stronger subgenual and adjacent ventral ACC activity with meditation. This brain area is involved with emotion regulation and attention control. also the dorsal lateral PFC and amygdala plays some role in regulation of emotion.

Self-awareness

Self-awareness includes the awareness of one self, the awareness of being conscious as well as meta-awareness which is the awareness of the internal bodily state. Regions of the brain involves midline cortical structure DMN, ACC, the insula, medial PFC and PCC. Reduce activity in midline cortical structure including the DMN, more reduction in the posterior part PCC, than the antoerior part medial PFC, but increase in perigenual ACC activity.

Meditation practice

Different expertises of meditation, early, middle, advanced appear to modulate the dynamic balance between anterior and posterior midline networks involved in different aspects of self, cognitive self, bodily self, and phenomenal experiential self. This reflects self plasticity following meditation. The effort to get into the meditative state takes 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 determine how much effort one must use to get into the meditative state [17]. These stages is illustrated in figure 2.3.

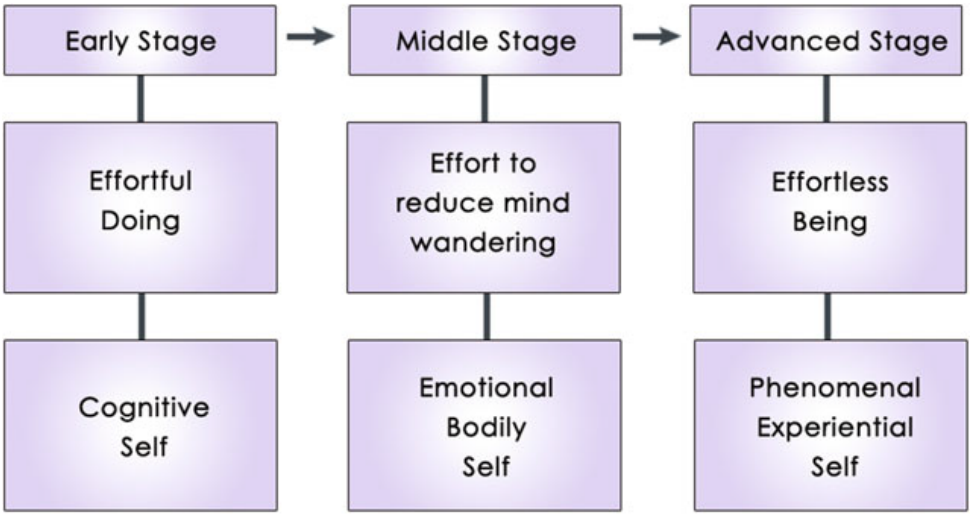

Figure 2.3: The three stages of meditation practice, describing how much effort one must use to get into the meditative state
[17]

In the early stages more mental effort is required, here the dorsal lateral PFC and partial cortex are often involved and activated more. A stronger deactivation in the DMN is shown to occur when using more effort. With less effort, the ACC and striatum will participate more. [17]

The method of mindfulness meditation will not make the pain go away, but the patient will be able to deal with the pain easier, as mentioned, making the patient engage more in the treatment than focusing on and reeling on the medication. [19] Even short-term mindfulness training can have an effect. The study by [**Zeidan2012**] is explaining an effect of training mindfulness meditation examined for 20 min sessions for four days of mindfulness meditation, but most studies conduct the experiments for a period of more than six weeks. [**Zeidan2012**]

The neural mechanisms behind mindfulness meditation in reliving pain has been researched and in experiments where stimulating with nociceptive pain there has been shown an increase in activity areas of the PFC when meditating. Participants telling that they are able to feel the pain but able to deal with it better during meditation focusing on the breath. The same mechanisms working in analgesia is not the same as the mechanisms during meditation, why the two methods don't interfere with each other. [19]

The different areas of the brain show either a reduction or increase in activity when performing meditation. When practicing meditation the person trains the mind, and areas of specific regions will grow. [**Zeidan2012**]

Examining long term meditators, the findings are a thicker gray matter in mid cingulate cortex and bilateral secondary somatosensory cortex, which are involved in pain related

regions overlapping the functional effect. A correlation with the number of years practicing meditaiton and the mid cingulate was also found. This gives evidence to long lasting effects of meditation. [**Zeidan2012**]

3 | Methods

3.1 Protocol

3.1.1 Hypothesis

- Pain can be positively affected by mindfulness.
- Pain, short-term meditation, mindfulness, pain threshold increased,
- Literature show a relieve of pain after meditation. Mindfulness meditation after brief training reduces pain.(Zeidan)
- Does short-term mindfulness meditation affect the pressure pain threshold (and pain tolerance)?

Hypothesis: Short-term mindfulness meditation increases the pressure pain threshold and the pressure pain tolerance.

3.1.2 Purpose

3.1.3 Subjects

Twenty (more better)healthy subjects were recruited for the experiment (x male, y female,mean age=Z).(We want same amount of male and female if it is possible). Specific inclusion and exclusion criteria have been formed for this experiment. It is not necessary that subjects believe in the effect of mindfulness meditation.

Inclusion criteria

- Healthy subjects age between 20-30 years
- Must have time to meditate for 4-5 days, 20 minutes per day.
- Normal BMI (F: 19-24 M: 20-25)

Exclusion criteria

- Ongoing meditation practice

- Acute or chronic pain
- Pregnancy
- Neurological, musculoskeletal or mental illness
- Lack of ability to cooperate
- Signs or symptoms of any serious systemic diseases
- Psychiatric, analgesic or other medications that might influence their response to pain
- Abusive drug or alcohol use

3.1.4 Setup

The Pressure Pain Threshold (PPT), defined as the pressure at which the sensation changed from pressure to pain, has been recognized as an effective and reliable way to quantify pain measures. In this study PPT was measured using (our ALGOMETER). PPT were measured in (point of the wrist). Testing points were marked to ensure reliable and rapid location during the experimental procedure. (The algometer was applied/ The examiner perform the measures) three times and the average of the registrations was filed. The subjects had a (5-10min??) resting time between measurements. PPT values were measured two times, the first day of the study and after 4-5 days since the first measure.

3.1.5 Approach

For this particular experiment a parallel study was conducted. The subjects recruited for the experiment were randomly assigned in two different groups, the control group or the treatment group.(equal number of male and female?). The control group consisted of X subjects no meditation. The treatment group consisted of Y subjects meditation

3.1.6 Procedure

Control group Treatment group

4 | Data analysis

5 | Results

6 | Discussion

7 | Conclusion

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8 | Appendices