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

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Abstract

Introduction: *Studies show that long-term mindfulness meditation provides the ability to enhance a broad spectrum of cognitive health outcomes on chronic pain patients. However, there are not many studies which show the effect of short-term mindfulness on chronic neck pain. The purpose of this study was to determine if short-term mindfulness focused attention meditation can alter pain sensitivity in healthy subjects. Even though the study was conducted in healthy subjects, the effects of meditation to pain sensitivity can be transferred to chronic pain patients.* ***Methods:*** *42 subjects were recruited for a control trial. To evaluate the pressure pain threshold and tolerance, pressure pain was applied with an algometer on the right upper trapezius in two measurements session with 5 days in between. The treatment group practiced 20 minutes of mindfulness focused attention meditation on 5 consecutive days between the two measurements, whilst the control group continued their normal routine.* ***Results:*** *Two-way mixed ANOVA showed no significant difference between control and treatment group in threshold ($p = 0.321$, $p = 0.507$) and tolerance ($p = 0.080$, $p = 0.472$). T-test showed no significant difference in the relative difference between first and second measurement of threshold ($p = 0.149$) and tolerance ($p = 0.330$).* ***Conclusion:*** *Nevertheless this study still contributes to the field of pain relief using mindfulness meditation. Since this study shows the tendency that mindfulness focused attention meditation increases both, threshold and tolerance, a longer period of practicing mindfulness focused attention meditation should be investigated.*

I. Introduction

Approximately 20 % of the world population suffer from chronic pain [1]. The characteristic of chronic pain is a duration of pain 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, maintaining an independent lifestyle and relationships to friends and family can be affected. A survey in nine European countries by Breivik et al. [3] showed that pain has an impact on the work life, whereby 25% of the patients indicated that they changed their job, responsibilities at job or lost their job due to chronic pain. Furthermore, depression was diagnosed in 21 % of those patients. [3]

One of the most common types of chronic pain is neck pain, as 25 % suffer from this in the UK [1]. Those patients are restricted by negatively affected fatigue and concentration [4]. Furthermore, they suffer like the majority of chronic pain patients from anxiety and depressed mood, cognitive distress and the resulting physical limitations [5].

At the moment there is no complete cure for chronic pain for the majority of the patients. The current treatment methods only provide possibilities to relieve the pain. [6, 7] Nevertheless, the majority of the patients feels pain daily and this pain increases throughout the day due to daily activities [3]. Chronic pain is mainly treated by medication. However, medications have side effects like abuse or organ damage. To avoid those risks, alternative methods can be used. [6, 7, 8] One of those methods

is mindfulness meditation, which uses meditation as mental training to achieve diminished judgment of emotions, cognitive control and existential insight. There are several types of meditation techniques. One of the most common is focused attention (FA), which is suitable for beginners and trains the concentration by focusing on an object or specific thing, often the sensation of breath. [9, 10]

Previous studies show that mindfulness meditation was able to enhance a broad spectrum of cognitive health outcomes, such as improvements of emotion regulation, cognitive control and positive mode. Furthermore stress, depression and anxiety can be relieved. These improvements are due to practicing mindfulness meditation, especially because of the mental training in emotion regulation, cognitive control, acceptance and positive mood. [7, 9, 11] Nevertheless, there are not many studies which investigating the effect of mindfulness meditation on chronic neck pain [1]. Additionally, most studies investigated the outcomes of practicing mindfulness meditation over a time period of two months or longer. The effect of a shorter time period of mindfulness meditation on chronic neck pain is not investigated yet.

The present study address if mindfulness FA meditation can alter pain sensitivity in the neck by measuring pressure pain threshold (Threshold) and pressure pain tolerance (Tolerance) in healthy subjects. 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 [12]. The upper trapezius is involved in chronic neck pain and this muscle present lower pressure pain threshold values compared with other muscles [13, 14], wherefore it was chosen as location for pressure application. Therefore the hypothesis *"Short-term mindfulness focused attention meditation on 5 consecutive days increases the pressure pain threshold and pressure pain tolerance in the right upper trapezius"* was tested.

II. Methods

i. Subjects

42 healthy subjects, 21 female and 21 male were recruited (age: 23.93 $\pm$ 2.74 years, BMI: 23.66 $\pm$ 3.28). Subjects with ongoing meditation practice, acute or chronic pain, neurological, musculoskeletal or mental illness, pregnancy or taking medications that might influence their pain sensitivity were excluded.

ii. Study Design

A controlled trial was designed, whereby the subjects were assigned into a control and treatment group with an equal gender distribution, as illustrated in Figure I.

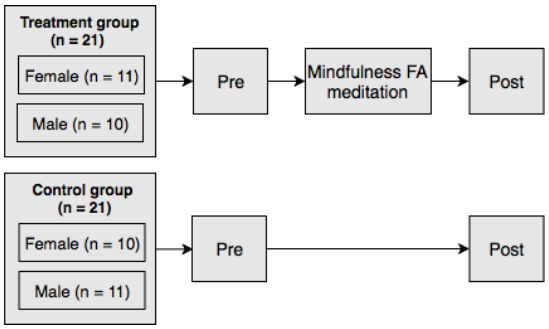

Figure I: *Parallel study design, whereby subjects were assigned to either treatment or control group, striving an equal gender distribution. The treatment group was meditating on 5 consecutive days between the first (Pre) and second measurement (Post), whilst the control group continued their normal routine.*

The subjects of the treatment group practiced 20 minutes mindfulness FA meditation on 5 consecutive days between the two measurements, while the subjects of the control group continued their normal routine. The same time interval between the measurement sessions was used for the two groups.

iii. Measurements

The location where the pressure was applied shown in Figure II, was marked at the right

upper trapezius in the midpoint between the acromion and 7th cervical vertebra to ensure reliable and rapid location during the experimental procedure.

Threshold and Tolerance were measured with an algometer (Wagner Force Ten^{TM} Digital force Gage). Three repetitions with a 5 minutes resting period in between were conducted. The examiner was blinded during the measurements to avoid bias. The mean of the three repetitions, was computed as measurement value.

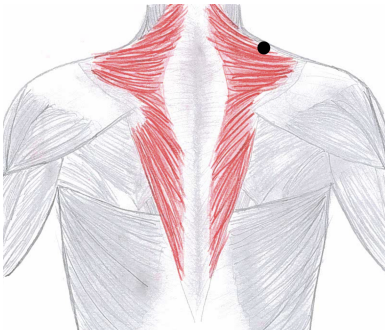

Figure II: *Location of pressure application on the right upper trapezius marked with a black dot.*

iv. Meditation Technique

The treatment group practice short-term mindfulness FA meditation with 20 minutes of meditation on 5 consecutive days. To ensure same meditation conditions, a guided meditation in form of an audio file was used. The used meditation technique was FA focusing on the flow of breath. The used audio file contains Buddhist meditation music [15], which is playing in the background consistently, and a male voice [16], which provides guidance through the meditation from time to time. The male voice explains in the beginning to focus the attention on the sensations of breathing and reminds from time to time to bring the focus back to the breath.

A short oral introduction to mindfulness FA meditation was provided before the first meditation session.

v. Data Analysis

At first the normality of the data samples was evaluated with a Shapiro-Wilk test and the equality of variances was evaluated with a Levene's test.

According to the outcome of the Shapiro-Wilk test and the Levene's test, ANOVA and t-test were chosen. The two-way mixed ANOVA was used, whereby factor 1 denotes the group of subjects, either treatment or control, and factor 2 denotes the measurement session, either the first (Pre) or the second (Post). Therewith the statistical significance of two variations was evaluated, the between-subjects variation in factor 1 and the within-subjects variation in factor 2. [17] Threshold and Tolerance have been analyzed with separate two-way mixed ANOVAs.

The t-test was used to compare the changes in Threshold and Tolerance between the measurement sessions of treatment and control group. Therefore the difference relative to Pre measurement (relative difference) between Pre and Post measurement in Threshold and Tolerance was calculated for each subject. A t-test was applied to the relative differences to test the mean difference between treatment and control group's relative difference [17]. Threshold's and Tolerance's relative difference have been analyzed separately.

III. Results

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

i. Two-way Mixed ANOVA

The Shapiro-Wilk test showed a normal distribution and the Levene's test showed equal variances for the Threshold and Tolerance Pre and Post for both, treatment and control group. Therefore the two-way mixed ANOVA was applied. Hereby the Pre and Post measurements

of Threshold and Tolerance were compared to assess the within-subjects effect. The treatment and control group were compared to assess the between-subjects effect. The results from the two-way mixed ANOVA are illustrated in Table I for Threshold and Table II for the Tolerance.

Table I: *Two-way mixed ANOVA for the Threshold Pre and Post 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.*

Within-Subjects Effect			
	df	**F**	**p**
Measurement	1	13.052	0.001*
Measurement x Group	1	0.451	0.507
Between-Subjects Effect			
	df	**F**	**p**
Group	30	1.492	0.231

The test indicates that there is a significant main effect between Pre and Post of the Threshold measurements (within-subject effect, Measurement), F(1,30) = 13.051, p = 0.001. However, no significant main effect is seen between the 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.

The test indicates that there is a significant main effect between Pre and Post of the Tolerance measurements (within-subject effect, Measurement), F(1,30) = 8.981, p=0.006. However, no significant main effect is seen between the 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.

Table II: *Two-way mixed ANOVA for the Tolerance Pre and Post 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.*

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

ii. T-test

The Threshold and Tolerance increases for both, treatment and control group, between the measurements. The relative difference in Threshold and Tolerance is illustrated in Figure III.

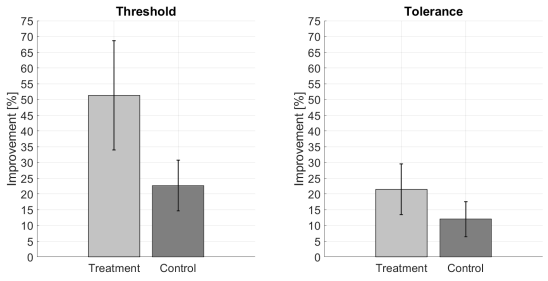

Figure III: *Relative difference for Threshold (left) and Tolerance (right) with associated standard error for treatment group (light grey) and control group (dark grey).*

The Shapiro-Wilk test showed a normal distribution. An unequal variance for the relative difference in Threshold and an equal variance for the relative difference in Tolerance was found for both groups. Therefore the t-test was applied. The results from the t-test are illustrated in Table III.
The test indicates that there is no significant difference in the relative difference in Threshold, F(1,19.892) = 6.967, p = 0.149 and Tolerance, F(1,30) = 2.084, p = 0.330 between the groups.

Table III: *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.*

Threshold		
df	**F**	**p**
19.892	6.967	0.149
Tolerance		
df	**F**	**p**
30	2.084	0.330

IV. Discussion

i. Summary and Interpretation of the Findings

A significant difference is found between the measurements, Pre and Post, indicated by the two-way mixed ANOVA. However, no significant difference in Threshold and Tolerance between treatment and control group is found. Furthermore, no significant difference in the 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. A study by Bingel et al. [18] showed, that healthy subjects habituate to pain over time. Furthermore a survey by Neddermeyer et al. [19] found out that the pain threshold of a person does not depend on the stimulus source. Hence the results show the habituation effect on pressure pain.

ii. Experimental Setup

The pressure application with an algometer should be conducted steady and consistent. 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. According to Kinser et al. [20] and Vaughan et al. [21] 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.

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. [22]

A study by Tesarz et al. [23] 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. [24] determines that high-intensity exercise is followed by hypoalgesia. Therefore Threshold and Tolerance values increase during and right after exercise [24]. On the other hand Serinken et al. [25] showed that Threshold is decreased 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.

iii. 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 mindfulness-based stress reduction. [10, 26] The effect on pain intensity and pain unpleasantness of short-term mindfulness meditation practice was shown by Zeidan et al. [11]. However, Zeidan et al. [11] used a meditation technique which combine FA and open monitoring, 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.

V. 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.

References

[1] Gary J. Macfarlanea. The epidemiology of chronic pain. *Pain in the joints*, 157:2158–2159, 2016.

[2] Bruna S. Mello, Tania M. Massutti, Vanessa K. Longaray, Daniela F. Trevisan, and Amalia de Fatima Lucena. Applicability of the Nursing Outcomes Classification (NOC) to the evaluation of cancer patients with acute or chronic pain in palliative care. *Applied Nursing Research*, 2016.

[3] Harald Breivik, Beverly Collett, Vittorio Ventafridda, Rob Cohen, and Derek Gallacher. Survey of chronic pain in Europe: Prevalence, impact on daily life, and treatment. *European Journal of Pain*, 10(4):287–287, may 2006.

[4] Carlijn H. van Randeraat-van der Zee, Anna J. H. M. Beurskens, Raymond A.H.M. Swinkels, Jan J.M. Pool, Roy W. Batterham, Richard H. Osborne, and Henrica C.W. de Vet. The burden of neck pain: its meaning for persons with neck pain and healthcare providers, explored by concept mapping. *Quality of Life Research*, 25:1219–1225, 2016.

[5] Anita Gross, Faith Kaplan, Stacey Huang, Mahweesh Kahn, Lina Santaguida, Lisa Carlesso, Joy MacDermid, David Walton, Justin Kenardy, Anne Söderlund, Arianne Verhagen, and Jan Hartvigsen. Psychological Care, Patient Education Orthotics, Ergonomics and Prevention Strategies for Neck Pain: An Systematic Overciew Update as Part of the ICON Project. *The Open Orthopaedics Jurnal*, 7:530–561, 2013.

[6] Jason E. Pope and Timothy R. Deer. *Treatment of Chronic Pain Conditions*. 2017.

[7] Dawn A. Marcus. *Chronic Pain*. 2009.

[8] Christoph Stein. *Analgesia*. 2007.

[9] Fadel Zeidan and David R. Vago. Mindfulness meditation–based pain relief: a mechanistic account. *Annals of the New York Academy of Sciences*, 1373(1):114–127, 2016.

[10] Jon Kabat-Zinn. An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation: Theoretical considerations and preliminary results. *General Hospital Psychiatry*, 4(1):33–47, apr 1982.

[11] R. F. Zeidan, J. A. Grantb, C. A. Browncc, J. G. McHaffiea, and R. C. Coghilla. Mindfulness meditation-related pain relief: Evidence for unique brain mechanisms in the regulation of pain. pages 265–275, 2012.

[12] Heidi Kjøgx, Helge Kasch, Robert Zachariae, Peter Svensson, Troels S Jensen, and Lene Vase. Experimental manipulations of pain catastrophizing influence pain levels in patients with chronic pain and healthy volunteers. *Pain*, 157(6):1287–1296, 2016.

[13] Andrew A. Fischer. Pressure algometry over normal muscles. Standard values, validity and reproducibility of pressure threshold. *Pain*, 30(1):115–126, 1987.

[14] D. Falla. Unravelling the complexity of muscle impairment in chronic neck pain. *Manual Therapy*, 9(3):125–133, 2004.

[15] NuMeditationMusic. Buddhist Meditation Music for Positive Energy: "Inner Self", Buddhist music, healing music 42501B, 2018.

[16] David Noyce. Focused Attention Meditation ˜ Sensations of Breathing (20 Minutes, 1.5 Min Intro), 2018.

[17] Erik Mooi, Marko Sarstedt, and Irma Mooi-Reci. Hypothesis Testing & ANOVA. In *Market Research: The Process, Data, and Methods Using Stata*, pages 153–214. Springer Singapore, Singapore, 2018.

[18] U. Bingel, E. Schoell, W. Herken, C. Büchel, and A. May. Habituation to painful stimulation involves the antinociceptive system. *Pain*, 131(1-2):21–30, 2007.

[19] Till J. Neddermeyer, Karin Flühr, and Jörn Lötsch. Principle components analysis of pain thresholds to thermal, electrical, and mechanical stimuli suggests a predominant common source of variance. *Pain*, 138(2):286–291, 2008.

[20] Ann M Kinser, William A Sands, and Michael H Stone. Reliability and Validity of a Pressure Algometer. *Journal of Strength and Conditioning Research*, 23(1):312–314, jan 2009.

[21] Brett Vaughan, Patrick McLaughlin, and Cameron Gosling. Validity of an electronic pressure algometer. *International Journal of Osteopathic Medicine*, 10(1):24–28, 2007.

[22] David Yarnitsky and Michal Granot. Quantitative sensory testing. *Handbook of Clinical Neurology*, 2006.

[23] Jonas Tesarz, Alexander K. Schuster, Mechthild Hartmann, Andreas Gerhardt, and Wolfgang Eich. Pain perception in athletes compared to normally active controls: A systematic review with meta-analysis. *Pain*, 153(6):1253–1262, 2012.

[24] Kelli F. Koltyn. Exercise-Induced Hypoalgesia and Intensity of Exercise. *Sports Medicine*, 32(8):477–487, 2002.

[25] Mehmet Akif Serinken, Celal Gençoğlu, and Berkant Muammer Kayatekin. The effect of eccentric exercise-induced delayed-onset muscle soreness on positioning sense and shooting percentage in wheelchair basketball players. *Balkan Medical Journal*, 30(4):382–386, 2013.

[26] Steven Rosenzweig, Jeffrey Greeson, Diane Reibel, Joshua Green, Samar Jasser, and Denise Beasley. Mindfulness-based stress reduction for chronic pain conditions: Variation in treatment outcomes and role of home meditation practice. *Journal of Psychosomatic Research*, 68(1):29–36, 2010.