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ORIGINAL ARTICLE

Regular use of acupressure mats reduces perceived stress at subjective but not psychophysiological levels: Insights from a three-week relaxation training

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Abstract

Acupressure mats are promoted as stress management tools for easy and effective self-application, promising reduced stress and increased well-being. However, the scientific evidence for these effects is based on few experimental studies and lacks the examination of acupressure mats as a solitary relaxation tool. Our study aimed to examine which changes in stress and well-being can be expected from the use of acupressure mats by healthy young people on the subjective and psychophysiological level. Unexperienced participants practiced relaxation for three weeks either with an acupressure mat or without any tools (active control group [CG]). As a results, subjective well-being and stress decreased, while sleep quality and concentration endurance increased across groups. Blood pressure (BP), heart rate (HR), pain threshold and pain tolerance did not change significantly from pre- to post-training measurements. Most importantly, no significant

Abbreviations: AMG, acupressure mat group; BP, blood pressure; BPM, beats per minute; CG, control group; CPT, Cold Pressor Test; HR, heart rate; NA, negative affect; PA, positive affect; PANAS, Positive and Negative Affect Schedule; PSQ, Pain Sensitivity Questionnaire; PSQI, Pittsburgh Sleep Quality Index; PSS, Perceived Stress Scale; TS, total score; WHO-5, World Health Organization — Five Well-Being Index.

differences were found between groups, indicating that training with an acupressure mat yielded no superior effects compared with an active control condition in healthy young students. As a conclusion, taking time to relax has some but limited beneficial effects on the subjective levels independent of the specific method for healthy students. Potential beneficial effects of acupressure mats might be bound to specific impairments, such as tension pain.

KEYWORDS

acupressure mats, blood pressure, relaxation training, stress, well-being

INTRODUCTION

Amidst an ongoing global pandemic (Manchia et al., 2022; Patterson et al., 2021), stress management skills seem more important than ever to maintain and promote mental health. Initial studies on the pandemic's consequences point towards a crucial risk for adolescents and young adults: While older age groups seem to be relatively more strongly affected by the physical health risks, younger age groups are more vulnerable to depression, anxiety, and stress symptoms (Maia & Dias, 2020; Varma et al., 2021). Foremost, the latter is considered an important risk factor impacting both mental and physical health (Satyjeet et al., 2020; Yaribeygi et al., 2017). The stress response alters attentional processes (e.g. Sänger et al., 2014), emotional responses (e.g. Raio et al., 2013), as well as how and what we remember from an experience (e.g. Schwabe et al., 2012). Over the long term, chronic stress may lead to various severe physical and mental impairments, for example, increases in muscle tension and pain (e.g. Abdallah & Geha, 2017; Cathcart et al., 2010), increased blood pressure (BP, e.g. Ayada et al., 2015), and sleeping disorders (e.g. Han et al., 2012). Against the context of several lockdowns, social isolation, and lifestyle or economic disruptions (Shanahan et al., 2022), methods of self-care and relaxation to cope with stress are becoming increasingly important not only for people who already suffer from health risks but also as a preventive method for generally healthy people.

Beside mindfulness trainings and meditation (e.g. Khoury et al., 2015; Schöne et al., 2018), acupressure gained interest as a self-applicable method to reduce stress (e.g. Honda et al., 2012; McFadden et al., 2012). So-called acupressure mats (also spike mat, bed of nails) are promoted for easy self-application. These mats are usually made of a foam cushion with a fabric cover sewn with small spike disks. Manufacturers of such mats proclaim that the regular use of such mats reduces the sensation of (tension) pain on the one hand, and improves well-being, relaxation, energy, and sleep quality on the other hand (e.g. ShaktiMat (ShaktiMat GmbH, n.d.-a), BODYMATE (AllMates GmbH, n.d.), and BACKLAxx (RESLA GmbH, n.d.)). Given these qualities, such mats would definitely deserve their popularity and would make a valuable tool for people who want to prevent stress-related complaints or tackle them at a sub-clinical level. However, to date, the scientific background regarding the actual effects of using acupressure mats on mental and physical health is based on only few experimental studies. Acupressure itself has been shown to have generally positive effects on mental health (e.g. Honda et al., 2012; McFadden et al., 2012, for review, see Lee & Frazier, 2011). Applied by a professional practitioner, acupressure reduces the stress response on subjective and psychophysiological levels (McFadden et al., 2012) and self-administered acupressure on the neck comes in with decreased perceived stress (Honda et al., 2012). Both physical and mental stress is thought to cause muscle tension (e.g. Bansevicius et al., 1997; Cathcart et al., 2009; Lundberg et al., 1999; Westgaard, 1999). For example, generally pain-free persons manifest increased tension in shoulder, neck, and facial muscles in response to mental stress (Bansevicius et al., 1997; see also Lundberg et al., 1994). In a similar vein, persons suffering from chronic tension-type headaches respond more sensitive to pain under acute mental stress compared with controls (Cathcart et al., 2009). Vice versa, it is assumed that reducing muscle tension will facilitate the reduction of stress (Lee & Frazier, 2011; Westgaard, 1999; see also Schöne et al., 2018). This inverse relationship might affect aforementioned improvements in both physical and mental health because of reducing tension pain through acupressure (see e.g. Chen & Wang, 2014; Hsieh et al., 2010).

Yet to the best of our knowledge, the effects of acupressure mats used by laypersons have been investigated in only two experimental studies (Kjellgren et al., 2011; Olsson & Von Schéele, 2011). In an exploratory study, Olsson & Von Schéele (2011) combined the use of an acupressure mat with relaxing music and relaxation instructions to investigate its effects on the psychophysiological level. While using the acupressure mat, participants reported initial pain that gradually subsided as relaxation increased. This transition from pain to relaxation was reflected in an acute increase in BP and back temperature, as well as a decrease in heart rate (HR) and skin conductance, indicating increased sympathetic and parasympathetic nervous system activity in direct comparison with lying on a mat without acupressure. However, while the relaxation instructions had no effect on the participants' subjective ratings, the authors (Olsson & Von Schéele, 2011) pointed to the positive effects of the slow breathing that the participants were instructed to do. Thus, the observed relaxation could not be attributed solely to the use of the acupressure mat (Olsson & Von Schéele, 2011).

Going one step further, Kjellgren et al. (2011) investigated the effects of acupressure mats as a self-care treatment over a four-week interval. In contrast to Olsson & Von Schéele (2011), they recruited patients suffering from muscle tension pain instead of a healthy sample. After using the mat for 15 min per day for three weeks, participants reported a significant reduction of their maximal experienced muscle pain intensity, but their average pain experience remained unchanged. Furthermore, no significant changes in depression, anxiety, optimism, stress, energy, and sleep quality were found, even though participants anecdotally reported positive effects on aforementioned psychological variables (Kjellgren et al., 2011).

Since previous studies investigated the effects of acupressure on stress and well-being either in clinical samples or in combination with additional relaxation methods only, our study systematically examines the effects of regular, self-administered use of an acupressure mat in isolation from other relaxation methods on the stress experience in a healthy norm sample. Our study aims to quantify which effects on stress and well-being can be expected on a subjective and psychophysiological level when acupressure mats are regularly used by healthy, young laypersons from a student population. Based on the two aforementioned studies (Kjellgren et al., 2011; Olsson & Von Schéele, 2011), as well as the effects usually promoted by the manufacturers, we expected that after regular use of the acupressure mat, well-being and sleep quality would increase, and experienced stress and pain sensitivity would decrease (see Honda et al., 2012). While acute stress might increase the performance in cognitive tasks (see e.g. Gaillard, 2018), longer term or even chronic stress impairs cognitive functioning (for review see e.g. Marin et al., 2011). Hence, while we hypothesized stress to decrease in response to relaxation, we expected the ability to concentrate on tasks to increase (Schöne et al., 2018). These changes on the subjective level and in cognitive abilities were hypothesized to be reflected on the psychophysiological level. In particular, BP and HR are positively associated with stress (Ayada et al., 2015; Kudielka et al., 2004; Taelman et al., 2008), and relaxation trainings aim at decreasing both of the former over the long term (Pal et al., 2014). Hence, we expected decreased BP and HR after three weeks of acupressure mat-based training (Ayada et al., 2015; Kudielka et al., 2004; Taelman et al., 2008). In addition to reducing tension pain, acupressure mats also facilitate habituation to the pressure pain caused by lying on the spikes of the mat, which might decrease the general sensitivity to pain. Hence, to examine whether acupressure has an effect on pain sensitivity and tolerance beyond subjective self-reports (see e.g. Kjellgren et al., 2011), we implement a cold pressor test (CPT). The CPT allows for the estimation of the pain threshold and tolerance by immersing the participants hand in icy water (Hellström & Lundberg, 2000). Because of the habituation observed in previous acupressure mat studies (Kjellgren et al., 2011), the individual pain threshold and pain tolerance were hypothesized to increase from pre- to post-training measurements in the acupressure mat group (AMG). Yet the CPT also functions as a stress inducing protocol (see e.g. Ishizuka et al., 2007; Larra et al., 2015; Silverthorn & Michael, 2013). If the relaxation training results in an improvement in stress management in terms of coping with an acute stressor, it would be expected to be reflected in an increased pain tolerance (see e.g. Mohammed et al., 2018).

In summary, our study aims to examine which effects on stress and well-being are associated with the regular use of acupressure mats in healthy young persons on the subjective and psychophysiological levels. Based on previous results (e.g. Kjellgren et al., 2011; Olsson & Von Schéele, 2011), we hypothesize that using an acupressure mat will decrease stress and increase well-being, which is both proposed to be reflected on the subjective level in increased reported well-being and sleep quality, as well as decreased perceived stress and pain sensitivity. Regarding objective measures, we assume increased concentration endurance, pain threshold and pain tolerance as well as decreased BP and HR.

METHODS

Participants

The sample size was determined based on previous studies applying a similar study design (Kjellgren et al., 2011; Olsson & Von Schéele, 2011) and aimed for 30 participants per group. Ninety-four participants were recruited from the student population of Osnabrück University and underwent a screening for psychological and neurological disorders (anamnesis; e.g. sleeping disorders, affective disorders, schizophrenia, epilepsy, substance abuse), complemented by a screening for physical conditions for which the use of an acupressure mat is not recommended according to the manufacturers (e.g. pregnancy, intake of blood thinners, cardiovascular diseases). Participants who met the respective psychological, neurological, or physical conditions were excluded from the study, as were those with prior experience with acupressure mats or meditation (excluded in total: $n = 24$). Eight additional participants voluntarily dropped out of the study after the anamnesis without stating a reason and without any data acquisition beyond the anamnesis (see also, Figure 1).

The remaining 62 participants were asked to lie down on an acupressure mat on a tryout basis for 2 min in the laboratory. No participant chose to refrain from participation in the study after trying out the acupressure mat. Informed written consent was obtained from all of them. In this course, two measurement appointments were scheduled with the participants (see Procedure). They were randomly assigned to one of the two relaxation trainings during the first measurement appointment (see Training; acupressure mat group (AMG): $n = 32$, $M_{\text{age}} = 22.85$, $SD_{\text{age}} = 0.58$, $M_{\text{BMI}} = 21.55$, $SD_{\text{BMI}} = 0.36$, 31 right-handed, 24 female, eight male; control group (CG): $n = 30$, $M_{\text{age}} = 22.30$, $SD_{\text{age}} = 0.53$, $M_{\text{BMI}} = 21.73$, $SD_{\text{BMI}} = 0.44$, 27 right-handed, 23 female, seven male).

Measures

Positive and Negative Affect Schedule (PANAS)

The Positive and Negative Affect Schedule (PANAS) assesses positive and negative affective states by means of a self-rating, represented in two subscales, positive affect (PA) and negative affect (NA). Both scales range from 0 to 50, with 50 indicating maximal intensity of positive/negative affect (Krohne et al., 1996).

World Health Organization — Five Well-Being Index (WHO-5)

The World Health Organization — Five Well-Being Index (WHO-5) assesses the current well-being of the participants and refers to the preceding two weeks. All items are positively phrased. The score ranges from 0 to 25, with 25 indicating the highest well-being (Bech, 1998).

Perceived Stress Scale (PSS)

The Perceived Stress Scale (PSS) measures the perceived stress with reference to the previous month by means of a self-rating. The total score (TS) ranges from 10 to 50, with 50 indicating the highest level of perceived stress (Schneider et al., 2020).

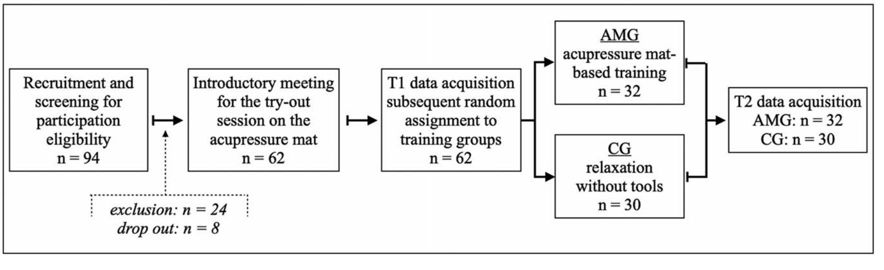

FIGURE 1 Flowchart of the participants' enrollment.

Pain Sensitivity Questionnaire (PSQ)

The Pain Sensitivity Questionnaire (PSQ) measures pain sensitivity based on the participants rating of painful everyday situations, for example, touching something hot. The TS ranges from 0 to 170, with 170 indicating the highest pain sensitivity (Ruscheweyh et al., 2009).

Pittsburgh Sleep Quality Index (PSQI)

The Pittsburgh Sleep Quality Index (PSQI) assesses sleep quality by means of a self-rating. The items refer to the previous four weeks. The TS ranges from 0 to 21 and lower values indicate higher sleep quality. Participants with a TS below or equal to 5 are considered healthy sleepers (Hinz et al., 2017).

Blood pressure (BP) and heart rate (HR)

The cardiovascular measures were obtained with a calibrated electric BP device (Beurer BM27; Beurer GmbH, Ulm, Germany) using the integrated upper arm cuff. The cuff was attached to the non-dominant upper arm. BP and HR were measured two times to circumvent higher values because of previous physical activity (e.g. if participants came to the lab by bike) or nervousness (e.g. white-coat hypertension, for review see e.g. Celis & Fagard, 2004). Only the second measurement was used for statistical analyses.

d2-test

The d2-test is a standardized neuropsychological test on concentration endurance, assessing sustained attention during a visual search task (Kaufmann et al., 1998). Participants are asked to cross out all ds with two dots among ds and ps with one, two, or three dots. The TS analyzed in this study was calculated as follows: total score = sum of all items considered regardless of errors *minus* the sum of all errors (omissions of ds with two dots, incorrectly crossed out letters that are not d's with two dots).

Cold Pressor Test (CPT)

The CPT was conducted to assess the participants' pain threshold and pain tolerance. Participants were asked to submerge their dominant hand up to their wrist into a bucket of 4°C cold water and keep it under water for as long as possible. They were instructed to inform the researcher as soon as they experienced pain instead of feeling cold (pain threshold) and to remove their hand from the bucket when they experienced the pain as unbearable (pain tolerance, see e.g. Hellström & Lundberg, 2000). The researcher measured the time in seconds for both events. The test was terminated by the researcher after 3 min if the participants did not pull their hand out of the water by then. Immediately before and after submerging the hand into the water, the surface temperature of the hand was determined using a conventional non-contact clinical thermometer to check whether the hand's surface temperature dropped during the CPT, but was not included in the analyses.

Procedure

The study was conducted in accordance with the Declaration of Helsinki and approved by the local ethics committee of Osnabrueck University. After the anamnesis, trying out the acupressure mat and obtaining informed written consents, two measurement appointments and a training phase were realized.

First measurement appointment

Each measurement appointment started with a resting phase. Participants were led into the laboratory and asked to take a comfortable seat, to sit still, calm down and not to talk for 5 min. After 5 min of rest, BP and HR were measured. Participants were then asked to fill in a set of questionnaires on their psychological state and well-being, including the German versions of the PANAS (Krohne et al., 1996), the WHO-5 (Bech, 1998), the PSS (Schneider et al., 2020), the PSQ (Ruscheweyh et al., 2009), and the PSQI (Hinz et al., 2017). The completing of the questionnaires was followed by a second five-minute resting phase and a second measure of BP and HR. The standardized d2-test was carried out in accordance with the test manual's standard instructions followed by the CPT. After the CPT, participants were given verbal instructions on how to do the relaxation training and received a training log including the instructions and training protocols. Those who were randomly assigned to the AMG were also given an acupressure mat to practice with at home.

Training

Participants were asked to train for three weeks and complete the training three times a week (see Training for details). They completed each training at home, not in the laboratory.

Second measurement appointment

Three weeks after the first measurement appointment, participants returned to the laboratory. Measurements of participants who got ill during the training phase (i.e. infections with SARS-CoV-19; AMG: n = 2; CG: n = 4) were postponed by a maximum of six days. During this time window, the respective individuals trained two more times if they felt well enough to do so. The participants returned the training log (both groups) and the acupressure mat (AMG only) at the beginning of the measurement. The test procedure followed exactly the same protocol as the first appointment, excluding the training's instructions. When all tests were completed, participants were offered to enter a lottery for the acupressure mats and all received partial course credits for participation.

Training

We implemented two different relaxation trainings: An experimental group trained with an acupressure mat (acupressure mat group; AMG) by ShaktiMat (original mat with 6,210 tips;

https://shaktimat.com/) and an active CG trained without any tools (control group; CG). The training instructions were based on the manufacturer's training recommendations (ShaktiMat GmbH, n.d.-b) in order to replicate the actual use by laypersons to the greatest possible extent.

Both groups were asked to train three times per week for 20 to 30 min per training for a period of three weeks. All participants were instructed to practice in the evening before going to bed. Before starting the training, they were to ensure a quiet atmosphere, that is, by preventing disturbances from other people and muting their smartphone, TV, music, and further potentially disturbing devices. For the relaxation training, they were to lay flat on their bed, bend their legs and close their eyes but stay awake. They were to remain in this position and state for 20 to 30 min. No task or instruction was directed towards their breathing or thoughts. After the training, they noted down short details about their daily routine and training time in a training protocol, as well as to document any irregularities (e.g. disturbances during training, headaches, illness).

Both groups followed exactly the same procedure with the one difference that the AMG was given an acupressure mat to train with. Instead of lying on their regular mattress, they were asked to place the acupressure mat atop their mattress and lay down with their whole back on the acupressure mat. If possible, they were to exercise with their backs bare. If the acupressure felt too intense to exercise for 20–30 min, they were allowed to wear a thin shirt. The CG followed exactly the same procedure without using an acupressure mat or any other tools.

Statistical analyses

Statistical analyses were performed using SPSS 27. The training frequency and average duration per training was compared using an unpaired *t*-test. All further subjective as well as psychophysiological measures were analyzed by means of a 2×2 rmANOVA per measure including the factors time (pre-training: T1, post-training: T2) and condition (AMG, CG). If the main effects or interaction reached significance, post hoc *t*-tests were performed for the respective measures. Cronbach's alpha was calculated for all questionnaires per time point of measurement (see Results).

RESULTS

According to the subjective measures at T1, participants were only mildly impaired in their sleep quality and mildly stressed across groups ($M_{\mathrm{PSQI}} = 6.83$, $SD_{\mathrm{PSQI}} = 1.66$; $M_{\mathrm{PSS}} = 26.6$, $SD_{\mathrm{PSS}} = 4.79$; see Figure 2). Their ratings of well-being ($M_{\mathrm{WHO}} = 14.77$, $SD_{\mathrm{WHO}} = 2.99$), experienced affect ($M_{\mathrm{PA}} = 27.15$, $SD_{\mathrm{PA}} = 5.23$; $M_{\mathrm{NA}} = 16.34$, $SD_{\mathrm{NA}} = 4.00$), and sensitivity to pain ($M_{\mathrm{PSQ}} = 69.68$, $SD_{\mathrm{PSQ}} = 17.08$) were in the middle range of the scales. Moreover, the cardiovascular values were in the normal to optimal range (blood pressure: $M_{\mathrm{systolic}} = 118$, $SD_{\mathrm{systolic}} = 11.11$; $M_{\mathrm{diastolic}} = 74$, $SD_{\mathrm{diastolic}} = 6.77$, see Mancia et al., 2013; heart rate: $M_{\mathrm{HR}} = 77.58$, $SD_{\mathrm{HR}} = 11.24$, see Avram et al., 2019). Their concentration endurance was very good according to the d2-test ($M_{\mathrm{d2}} = 487.92$, $SD_{\mathrm{d2}} = 71.49$; upper fourth quadrant of norm data, see Kaufmann et al., 1998). Hence overall, our sample can be classified as healthy norm sample across groups.

Participants of both groups did not differ with respect to their training frequency ($t(60) = -1.08$, $p = .28$, $d = .28$, $CI_d = [-0.77; 0.23]$) and average duration per training ($t(60) = 0.63$,

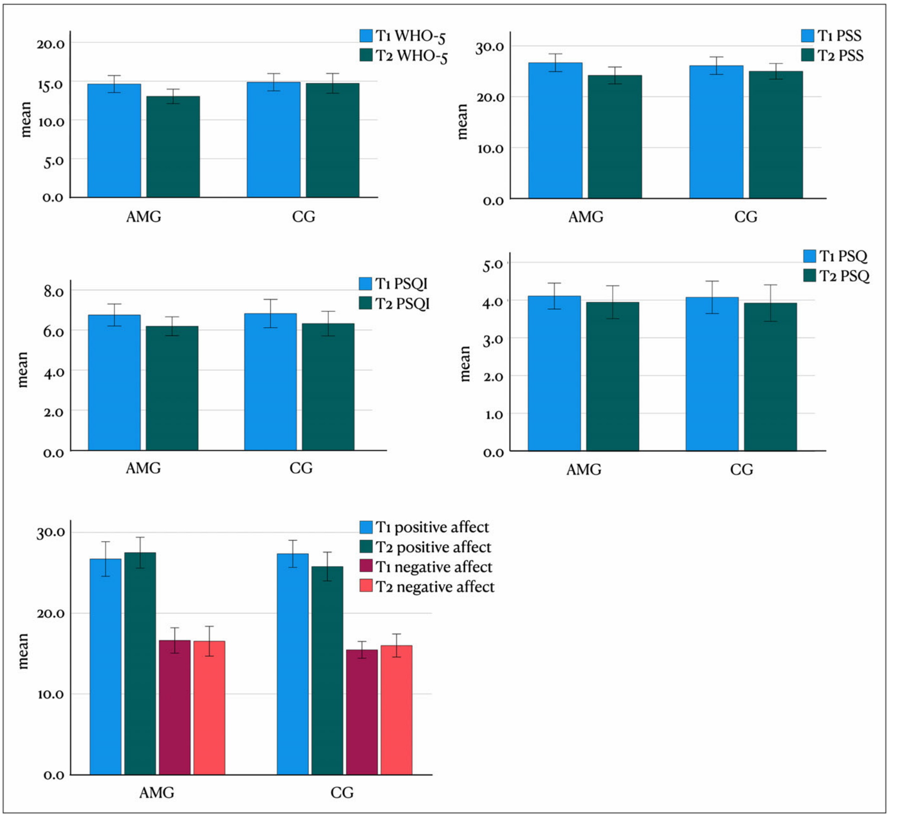

FIGURE 2 Descriptive statistics (mean) per measure, timepoint and group for the questionnaires. The error bars depict the confidence interval (95%) of the mean. T1 marks the measurement before the training phase, T2 the measurement after the training phase. Abbreviations: AMG, acupressure mat group; CG, control group; WHO-5, well-being; PSS, perceived stress; PSQI, Pittsburgh Sleep Quality Index; PSQ, Pain Sensitivity Questionnaire; PANAS, Positive and Negative Affective State. [Color figure can be viewed at wileyonlinelibrary.com]

$p = .53$, $d = .16$, $CI_d = [-0.34;\ 0.66]$). They trained on average 9.7 times ($SD_{\text{all}} = 1.22$; $M_{\text{AMG}} = 9.5$, $SD_{\text{AMG}} = 1.19$; $M_{\text{CG}} = 9.9$, $SD_{\text{CG}} = 1.25$) for 22.6 min per training ($SD_{AMG} = 3.4$; $M_{\text{AMG}} = 22.9$, $SD_{\text{AMG}} = 3.8$; $M_{\text{CG}} = 22.3$, $SD_{\text{CG}} = 2.9$). Thus, differences between groups cannot be traced to the time spent on training sessions.

Significant main effects of time (T1 versus T2) were found for subjective well-being (WHO: $F[1,\ 58] = 4.51$, $p = .038$, $\eta^2 = .072$), for perceived stress (PSS: $F[1,58] = 12.21$, $p = .001$, $\eta^2 = .174$), sleep quality (PSQI: $F[1,\ 58] = 4.59$, $p = .036$, $\eta^2 = .073$) and concentration endurance (d2: $F[1,\ 58] = 146.50$, $p < .001$, $\eta^2 = .72$). No further significant effects – neither main effects of time, nor main effects of condition, nor interactions of time and condition – were found (all Fs<3.88, all ps>.05; see Figure 2 and Table 1 for a detailed report and effect sizes). Paired post-hoc t-tests revealed that subjective well-being decreased by approx. 6% from T1 to T2 measurements ($t[59] = 2.21$, $p = .031$, $d = .29$). At the same time, perceived stress decreased by approx. 7% ($t[59] = 3.57$, $p = .001$, $d = .46$), while sleep quality ($t[59] = 2.18$, $p = .034$, $d = .28$) increased by approx. 8%. Sustained attention increased by approximately 11% ($t[59] = -12.12$, $p < .001$, $d = -1.58$). Please see Tables 1 and 2 for the full report of statistics and effect sizes and Figure 3 for descriptive statistics and confidence intervals.

TABLE 1 2 × 2 rmANOVA per measure and estimation of the effect size. The effect size partial eta squared ($\eta 2$) is interpreted as follows: a: small effect, $\eta 2 \geq .01$; b: medium effect, $\eta 2 \geq .06$; c: large effect, $\eta 2 \geq .14$ (see Miles & Shevlin, 2001). Please see Methods for the ranges per scale.

Measure	Effect	*df*	*F*	*p*	$\eta 2$
WHO-5	Time	1, 58	4.51	.038	.072[b]
	Condition	1, 58	2.21	.143	.037[a]
	Time * condition	1, 58	3.15	.081	.051[a]
PSS	Time	1, 58	12.21	.001	.174[c]
	Condition	1, 58	0.01	.912	<.001
	Time * condition	1, 58	1.82	.182	.030[a]
PSQ	Time	1, 58	2.69	.107	.044[a]
	Condition	1, 58	0.01	.920	<.001
	Time * condition	1, 58	<0.01	.958	<.001
PSQI	Time	1, 58	4.59	.036	.073[b]
	Condition	1, 58	0.10	.749	.002
	Time * condition	1, 58	0.02	.900	<.001
Positive affect	Time	1, 58	0.44	.511	.007
	Condition	1, 58	0.21	.651	.004
	Time * condition	1, 58	3.88	.054	.063[b]
Negative affect	Time	1, 58	0.16	.694	.003
	Condition	1, 58	0.87	.354	.015[a]
	Time * condition	1, 58	0.32	.576	.005
Systolic blood pressure	Time	1, 60	2.71	.105	.043[a]
	Condition	1, 60	0.12	.730	.002
	Time * condition	1, 60	0.88	.351	.015[a]
Diastolic blood pressure	Time	1, 60	2.92	.092	.046[a]
	Condition	1, 60	0.07	.800	.001
	Time * condition	1, 60	<0.01	.990	<.001
Heart rate	Time	1, 60	0.80	.376	.013[a]
	Condition	1, 60	0.37	.547	.006
	Time * condition	1, 60	0.01	.908	<.001
Pain threshold	Time	1, 58	0.30	.584	.005
	Condition	1, 58	1.64	.205	.028[a]
	Time * condition	1, 58	0.18	.672	.003
Pain tolerance	Time	1, 58	2.52	.118	.040[a]
	Condition	1, 58	0.13	.725	.002
	Time * condition	1, 58	1.15	.288	.019[a]
d2	Time	1, 58	146.50	<.001	.720[c]
	Condition	1, 58	0.25	0.620	.004
	Time * condition	1, 58	0.99	0.323	.017[a]

Abbreviations: PSS, Perceived Stress Scale; PSQ, Pain Sensitivity Questionnaire; PSQI, Pittsburgh Sleep Quality Index; WHO-5, World Health Organization — Five Well-Being Index.

TABLE 2 Post-hoc *t*-tests for the main effect of time and respective descriptive statistics per time point of measurement. The effect size Cohen's *d* is interpreted as follows: a: small effect, $d \geq .2$; b: medium effect, $d \geq .5$; c: large effect, $d \geq .8$ (see Cohen, 1988). Please see Methods for the ranges per scale. The lower and upper bounds of the 95% confidence interval (*CI*) of the effect size *d* are indicated respectively. Per time point and measure, the mean (*M*), standard deviation (*SD*) and standard error of the mean (*SE*) are given.

		M	*SD*	*SE*	*t*	*Df*	*p*	*d*	*CI*
WHO-5	T1	14.73	2.95	0.38	2.21	59	.031	.29[a]	[0.03; 0.54]
	T2	13.82	3.03	0.39					
PSS	T1	26.42	4.64	0.60	3.57	59	.001	.46[a]	[0.19; 0.73]
	T2	24.57	4.31	0.56					
PSQI	T1	6.78	1.66	0.21	2.18	59	.034	.28[a]	[0.02; 0.54]
	T2	6.25	1.43	0.19					
d2	T1	486.04	71.78	9.35	−12.12	58	<.001	−1.58[c]	[−1.96; −1.19]
	T2	537.17	66.41	8.65					

Abbreviations: PSS, Perceived Stress Scale; PSQI, Pittsburgh Sleep Quality Index; WHO-5, World Health Organization — Five Well-Being Index.

Cronbach's alpha

Cronbach's alpha indicated high reliability for most of the questionnaires for T1 and T2 (*T1*: positive affect: $\alpha = .81$; negative affect: $\alpha = .72$; PSS: $\alpha = .81$; PSQ: $\alpha = .90$; *T2*: WHO: $\alpha = .73$; positive affect: $\alpha = .79$, negative affect: $\alpha = .77$; PSS: $\alpha = .78$; PSQ: $\alpha = .93$). Few scales only reached acceptable to questionable reliability (*T1*, WHO: $\alpha = .58$) and the PSQI's reliability is unacceptable and thus limits the interpretability of the questionnaire (*T1*: $\alpha = .30$; *T2*: $\alpha = .27$).

DISCUSSION

Our study aimed to provide new insights into which effects on stress and well-being are associated with the regular use of acupressure mats in healthy young persons on the subjective and psychophysiological levels. To this end, participants trained relaxation for three weeks either using an acupressure mat (AMG) or without any tools (CG). Prior and subsequently to the training phase, subjective and psychophysiological measures of stress and well-being were assessed. Our results indicate that both groups' overall well-being, but also perceived stress decreased, while sleep quality and concentration endurance increased. However, no differences were found for psychophysiological measures pre- and post-training, as well as between groups which suggests that intentionally taking time to rest has a general effect on self-rated stress, well-being and sleep with the use of acupressure mats not being superior to an active CG.

On the subjective level, both training groups benefitted to the same degree from their respective relaxation training method: Their stress levels decreased, while sleep quality increased independent of the training method. Remarkably, their overall well-being decreased from the measurement before, to the measurement after the training phase. Since the second measurement took place later in the academic semester, the participants' well-being might have

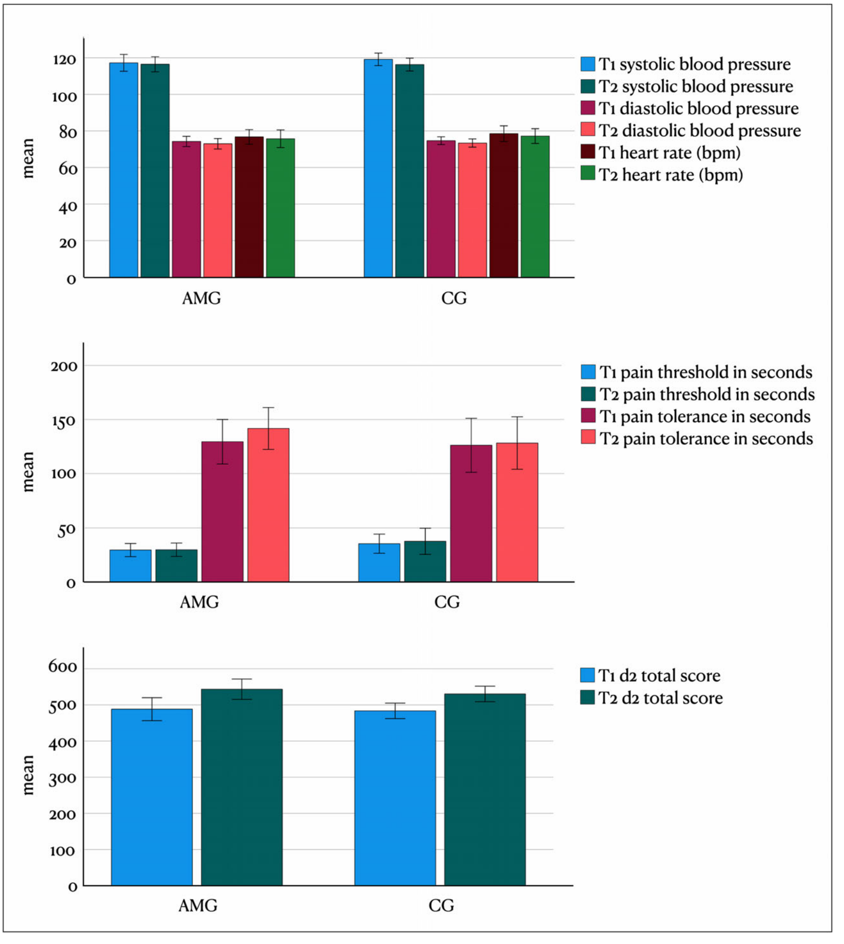

FIGURE 3 Descriptive statistics (mean) per measure, timepoint and group for the psychophysiological measures and the d2-test. The error bars depict the confidence interval (95%) of the mean. Abbreviations: AMG, acupressure mat group; BPM, beats per minute; CG, control group. T1 marks the measurement before the training phase, T2 the measurement after the training phase. [Color figure can be viewed at wileyonlinelibrary.com]

been affected by their study load or upcoming exams. However, this interpretation conflicts directly with the reported reduction in stress and improved sleep quality. As the WHO and PSQI questionnaires did not possess adequate reliability at both measurements for our sample (see Results), the interpretability of both results is limited. Yet the significant decrease in perceived stress argues for slight positive effects on the subjective level.

Concentration endurance increased between measurements but independent of the training method. The D2-test has an adequate retest reliability but albeit the large effect size, increases of approximately 25% are to be expected from practice effects in norm samples (Kaufmann et al., 1998). Our sample showed an increase of around 11%, which would therefore even be below the expectable learning effects. Despite the high effect size, this increase is therefore either hardly relevant or limited by a ceiling effect, since the participants already performed very well during the first measurement (see Results).

However, no measure beyond the self-ratings and concentration endurance yielded significant results, that is, no effects were found on the psychophysiological level. BP, HR, pain threshold and pain tolerance did not yield significant changes between measurements for either group. Stress and BP are positively related and relaxation methods aim to decrease BP and HR over the long term (Pal et al., 2014), indicating that the physiologically measurable stress level was similar during both measurements. Moreover, the pain threshold and tolerance were expected to increase because of the habituation to acupressure induced pain (Olsson & Von Schéele, 2011). Yet the CPT also functions as a stress inducing protocol (see e.g. Ishizuka et al., 2007; Larra et al., 2015; Silverthorn & Michael, 2013). That the participant's response to the CPT by means of pain threshold and tolerance did not change between measurements is a further indication that the participants response to an acute stressor was not significantly altered over the time course of the respective relaxation training.

Remarkably, the use of the acupressure mat did not yield any significantly different changes compared with a treatment without acupressure after three weeks of training. A previous study on acupressure found significant stress reductions after two weeks of self-administered treatment which was preserved even after four weeks (Honda et al., 2012), contradicting a too short training phase in our study. It is possible that longer or more frequent use, individual factors, or combination with other relaxation methods play a crucial role in the effectiveness of acupressure or, vice versa, other relaxation methods might benefit from the simultaneous use of an acupressure mat (Kjellgren et al., 2011). Yet in contrast to other acupressure trainings, acupressure mats stimulate a multitude of areas which might include both, specific acupressure points as well as unspecific areas. On the one hand, acupressure's effectiveness is often proposed to be closely related to the specific points that are pressed (for review, see e.g. Au et al., 2015). Moreover, the ability to discriminate between more than two simultaneous tactile stimuli is limited, for example, by the distance that needs to separate two tactile stimuli to be distinguishable (see e.g. Catley et al., 2013). In the case that sensing the very specific acupressure point is relevant to efficacy, global acupressure would potentially reduce its effectiveness. On the other hand, some studies do not find differences between the stimulation of known acupressure points and respective sham points (Melchart et al., 2006). To the best of our knowledge, no previous study includes a comparison of acupressure applied to single, specific acupressure points and the broader application of acupressure via an acupressure mat. Consequently, further examination is needed to estimate whether the broad acupressure by means of acupressure mats might reduce the effects of acupressure and indicates the need for comparisons between local, global and sham acupressure application.

Nevertheless, slight positive effects were observed across both groups on their ratings of perceived stress. Kjellgren and colleagues (Kjellgren et al., 2011) argued that reclining and relaxing alone might produce a feeling of increased well-being. In line with that, our results suggest that relaxation training per se is to some degree effective on the subjective level, regardless of the actual method.

Since our sample was only mildly impacted concerning stress and well-being (see Results for T1), potential effects may have been overshadowed by relatively little potential for improvement. Individuals with specific impairments, such as chronic pain (e.g. Kjellgren et al., 2011), might benefit more strongly from the use of an acupressure mat. Similarly, individual factors such as prior experience in meditation or openness to mindfulness-based methods might alter or mediate the effect of acupressure mats (Kjellgren et al., 2011; Olsson & Von Schéele, 2011). However, such clinical and differential factors were beyond the scope of the research question at hand.

Limitations

All measures were assessed at two time points, pre- and post-training phase, which is a standard procedure. However, this procedure renders it impossible to determine immediate effects, such as the increase in BP and skin temperature immediately during or directly after use (see e.g. Olsson & Von Schéele, 2011). It cannot be ruled out that self-administered acupressure via acupressure mats leads to a subjective and psychophysiological stress reduction in the short term, which was not revealed in this study. However, since our study intended to investigate longer-term effects, we see this limitation as unproblematic for the research question at hand.

In terms of pain threshold and tolerance, it is also possible that habituation to the pressure/pressure pain elicited by acupressure mats does not generalize across the whole body, that is, from the treated back to the hands. In the similar vein, habituation might affect only those specific sensory receptors that respond to acupressure, that is, mechanoreceptors, and does not generalize to other receptors, for example, thermoreceptors responding to the CPT. Nevertheless, the CPT provides information about the stress response and should therefore not be neglected.

CONCLUSION

In conclusion, both relaxation trainings came in with reduced stress and improved sleep quality but reduced well-being on the subjective level. Concentration–endurance increased but within the range of potential learning effects. Yet neither training method was superior nor yielded relevant changes on the psychophysiological level. Hence, our data indicate that acupressure mats come in with some beneficial effects for generally healthy students on the subjective level, but we found no evidence that their use is superior to an active control when used autonomously at home. In line with previous research (Kjellgren et al., 2011), actively taking time to relax might have beneficial effects for healthy young people on the subjective level which are independent on the specific relaxation method, but might still be beneficial to maintain mental health. As a practical implication, the least effortful trainings diminish stress as well and thus, reduce the hurdle and effort to perform them. Vice versa, this increases the likelihood that these trainings are actually carried out regularly. At the same time, however, it cannot be ruled out that a specific training such as with acupressure mats achieves superior effects on an individual level than a non-specific training. Longer or more frequent training, individual factors, or regarding specific impairments might potentially increase the effectiveness of a specific method, like the use of acupressure mats when suffering from tension pain.

AUTHOR CONTRIBUTIONS

All authors contributed to the study conception and design. Testing, data collection and data analyses were performed by JK. JK drafted the manuscript. BS provided critical revisions. All authors approved the final version of the manuscript for submission.

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CONFLICT OF INTEREST STATEMENT

All authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

The datasets generated during and analyzed during the current study are available in the OSF repository: https://osf.io/p6hu8/?view_only=bd9eba49445b4586b905ee647ac28a57.

ETHICS DECLARATIONS AND CLINICAL TRIAL REGISTRATION

The study was conducted in accordance with the Declaration of Helsinki and approved by the local ethics committee of Osnabrueck University. All participants gave informed written consent to participation in the study and to the publication of the anonymized data.

The study was post-registered with the German Register of Clinical Trials ("Deutsches Register Klinischer Studien", DRKS) on 23.02.2023. The registration can be found using the ID DRKS00031315 or the following link: https://drks.de/search/de/trial/DRKS00031315. The DRKS participates in the WHO International Clinical Trial Registry Platform and will publish this registration on the WHO portal (https://trialsearch.who.int) within 4 weeks after the DKRS-registration.

PERMISSION TO REPRODUCE MATERIAL FROM OTHER SOURCES

The manuscript includes no material from other sources.

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