Treating stress-related pain with the flotation restricted environmental stimulation technique: Are there differences between women and men?

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The aim of the present study was to explore, for the first time, sex differences among patients diagnosed with stress-related pain before and after flotation restricted environmental stimulation technique (REST) treatment, delivered 12 times during seven weeks. The present study included 88 patients (69 women, 19 men) from three different studies (post hoc analysis). They had been diagnosed by a physician as having chronic stress-related muscle tension pain. The analyses indicated that the flotation-REST treatment had beneficial effects on stress, anxiety, depression, sleep quality and pain and that there were few sex differences. Women were more depressed than men before treatment, but after treatment there was no difference between sexes. However, there was a sex difference in the ability to endure experimentally induced pain, suggesting that men exhibited greater endurance both before and after the flotation-REST treatment. The results also showed, for the first time, that both sexes improved their ability to endure experimentally induced pain (higher scores for upper pain threshold) following the successful flotation-REST pain treatment.

Key Words: *Anxiety; Flotation-REST; Pain; Sex differences; Stress*

Le traitement de la douleur liée au stress par la technique de stimulation en caisson de flottaison : Y a-t-il des différences entre les femmes et les hommes ?

La présente étude visait à explorer, pour la première fois, les différences selon les sexes entre les patients ayant reçu un diagnostic de douleur liée au stress avant et après un traitement REST par technique de stimulation en caisson de flottaison administré 12 fois en sept semaines. La présente étude incluait 88 patients (69 femmes, 19 hommes) provenant de trois études (analyse *a posteriori*). Un médecin avait diagnostiqué qu'ils souffraient de douleurs de tension musculaire chroniques liées au stress. Les analyses ont indiqué que le traitement REST avait des effets bénéfiques sur le stress, l'anxiété, la dépression, la qualité du sommeil et la douleur et que les différences étaient minimes entre les sexes. Les femmes étaient plus dépressives que les hommes avant le traitement, mais par la suite, les différences s'estompaient. Cependant, on constatait une différence selon les sexes dans la capacité d'endurer une douleur induite de manière expérimentale, ce qui laisse supposer que les hommes avaient plus d'endurance tant avant qu'après le traitement REST. Pour la première fois, les résultats ont également révélé que les deux sexes étaient mieux en mesure d'endurer une douleur induite de manière expérimentale (indices plus élevés de seuil de douleur maximale) après un traitement REST réussi.

People have been exposed to a society filled with increasing amounts of information and demands, resulting in increasing stress-related strains both at work and outside (1), a fact that implies costs to society estimated at a minimum of 3% to 4% of the gross national product of Sweden (2). Stress-related ill health has increased dramatically in the industrial setting, in white-collar and blue-collar domains, the medical setting, and the public health sector, as well as in telecommunications, information technology, and information and media (2). More women than men suffer from chronic pain (3,4).

Most patients seeking medical care for stress and stress-related pain are women (5). That is also the case for those visiting the stress clinic in the Human Performance Laboratory at Karlstad University (Karlstad, Sweden), where approximately 80% of visitors are women. At the clinic, patients are treated with deep relaxation in a flotation tank.

Flotation is a form of sensory isolation or, in contemporary terms, 'restricted environmental stimulation technique' (REST). The flotation form of REST involves placing the individual in a tank of water with an extremely high saline level – considerably higher than that in the Dead Sea. However, the salt is mainly magnesium sulphate, which does not irritate the skin. The opening of the tank is covered by a thin lid that can be easily opened and closed from inside. The tank is insulated on the inside to retain heat and exclude sound (ear plugs are also used) and light to complete darkness. With this technique, all incoming sensory impressions are reduced to a minimum. The temperature of the water is kept at 34.7°C, and a normal treatment time is 45 min twice a week.

Several early studies applied flotation-REST as a method for alleviating different kinds of painful conditions. Chronic headaches were improved by flotation-REST (6), improvements of rheumatic pain were observed (7) and premenstrual pain was alleviated (8); other studies indicating pain-reducing effects of flotation-REST have been performed (9,10).

Several more recent studies that applied flotation-REST as a method for alleviating chronic stress-related pain conditions have been performed (11,12). In a series of studies performed by the Human Performance group (13), it has been shown that a treatment schedule of 12 flotation-REST treatments twice a week for six weeks (over a total of seven weeks) is effective for most of the participants. The pain-reducing effects of the flotation-REST therapy were maintained at four months follow-up (13). Recent case studies also indicate good effects on fibromyalgia (14) and whiplash-associated disorders (15), even if these ailments often need longer periods of treatment.

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No conclusive evidence of the working mechanisms of pain reduction has been presented, but the impact of deep relaxation and subsequent reduction of stress hormones (12,16) that cause pain may be contributors. It has been suggested that pain-reducing endogenous endorphins (eg, beta-endorphin) are released because of the tank treatment (17,18), but this has not been satisfactorily proven (12). The pain-reducing mechanisms probably involve several complicated interactions concerning endogenous compounds (eg, endocannabinoid system, stress hormones and the opioid system). The effects of flotation-REST are not strongly influenced either by expectancy placebo (19) or attention placebo (20).

Several studies have reported other positive effects besides pain reduction (13), such as increased well-being, mild euphoria, increased originality, improved sleep, reduced stress, reduced tension and anxiety, reduced blood pressure and less muscle tension. A meta-analysis (21) investigated flotation as a stress management tool. The study examined 25 articles with a total of 449 participants and the results showed that the flotation technique has positive effects on physiology (eg, lower blood pressure), well-being and performance.

Women make up the majority of the participants in the clinical studies cited in the present study, which made statistical comparisons between sexes impossible. Because, to our knowledge, there are no studies in the literature of flotation-REST that specifically investigate possible sex differences in response to the flotation treatment, the need for such a study is pressing. Our general impression, after several years of research with flotation-REST, was that the method works in similar ways for both sexes. A further argument for studies dedicated to sex differences and pain is that nonpharmacological methods of all types are sparsely documented in this regard (22).

Chronic pain has several components beyond sensory features that are worth examining (eg, experience of control, level of stress, emotional activity and support from surroundings). Experimental pain processes are limited in their capacity to model chronic pain conditions (eg, the affective component is limited; in contrast to chronic pain a pain experiment may be terminated anytime; etc). Nevertheless, experimental pain studies have value in investigating mechanisms of pain. They also provide clues as to whether pain thresholds (PTs) of a patient are affected during treatment. In our flotation-REST treatment programs with chronic pain patients, we examined sensory detection thresholds (DTs) and pain endurance (PE) using a device (Pain Matcher, Cefar Medical AB, Sweden; see Methods) that delivers increasing electrical currents to the skin. This is performed both before and after the treatment period.

This is useful in the study of sex differences in relation to chronic stress-related pain because earlier findings indicated that men have higher PTs (ie, the lowest level of stimulation required to produce the first perception of pain) (23,24) and higher DTs (ie, the lowest level of stimulation that can be detected) (23). Men also seem to have higher levels of PE (ie, the ability to endure pain) (11). There have been discussions of whether the observed differences between men and women in regard to PT and PE represent sex differences in the pain experience or differences in how pain is expressed (25).

The aim of the present study was to explore possible sex differences among patients diagnosed with chronic stress-related pain before and after flotation-REST treatment.

METHODS

Participants

The present study combined data from 88 patients. Participants included 69 women and 19 men, all recruited from the waiting list at the Human Performance Laboratory at Karlstad University. They had all been diagnosed by a physician as suffering from stress-related chronic pain in the back and/or neck. Among the patients, 32 had also received a diagnosis of depression, including symptoms such as fatigue, diminished energy, loss of self-esteem, problems with organizing daily life, problems with memory and processing new information, problems with sleep, poor restoration by rest, and feelings of low mood. The mean (± SD) age of the patients was 49.28±9.24 years. An independent samples *t* test yielded no significant age difference with regard to sex (P=0.307). Furthermore, a Fisher's exact test indicated no significant difference concerning the distribution of patients with depression among men and women (P=0.789).

Design

The current study used a two-way split-plot design, with treatment assessments before and after 12 flotation sessions constituting the within-subjects factor and sex (men, women) constituting the between-subjects factor. The participants were treated with flotation-REST during two three-week periods consisting of two treatments (45 min each) per week for three weeks, followed by a week without treatment. The reason for having three-week treatment periods was so female subjects could plan the timing of their flotation treatments around the incidence of each menstrual cycle. Several measurements (degree of depression, anxiety, sleep quality and pain), as well as assessments of participants' sensory DTs and PE (using the electronic device Pain Matcher) were performed before and after the treatment period.

Instruments

Flotation tank: A flotation tank measuring 2700 mm × 1500 mm × 1300 mm was used. The depth of fluid (salt water) varied between 200 mm and 300 mm. The flotation tank was insulated to maintain a constant air and water temperature and to reduce incoming light (total darkness) and noise (ear plugs were used for total silence). The water temperature was maintained at 34.7°C and was saturated with magnesium sulphate (density = 1.3 g/cm^3). Each treatment session in the tank lasted 45 min and was performed twice a week.

Questionnaire 1: Before the first treatment, a questionnaire was provided that estimated each subject's self-assessed pain and experienced sleep quality. Each subject's description of 'sleep quality' was estimated on a visual analogue scale (0 to 100), while 'pain frequency' was estimated on a Likert scale (1 to 5; from 'rare pain' to 'pain day and night').

Questionnaire 2: Directly after the weeks of experimental flotation treatment, the same questions were posed.

Pain area inventory: The pain area inventory (PAI) (20) consists of two anatomical images of a human being, one frontal and one dorsal. The task of the participants was to indicate and

colour with a colour pen their areas of pain, and to report the nature of pain experienced and pain severity for the areas designated. This test was given both before and after the treatment period. For scoring, a transparent, plastic film was then placed over the coloured areas on both figures. Each figure was divided into 833 equal-sized squares (total 1666) and the number of coloured squares was calculated. The test was validated (20) through comparisons with other instruments by examining relationships with total number of pain types reported, number of connected pain areas, most severe pain intensity, normal pain intensity and pain frequency. The data yielded acceptable values (standardized item alpha = 0.84, R=0.70). Test-retest reliability was examined by using a group of pain patients who completed the PAI on two occasions, seven weeks apart (r=0.92).

Pain Matcher: The device called the 'Pain Matcher' is controlled by a microprocessor that provides rectangular pulses with a frequency of 10 Hz and amplitude of 10 mA. The instrument allows patients to demonstrate the level of electrical stimulation that would be equivalent to their clinical pain. Psychometric investigations indicate excellent reliability scores for PTs (r_a between 0.95 and 1.00) (26,27), but the validity of the instrument concerning assessments of pain levels has not been adequately determined (26). In the present study, subjects were first instructed to release their grip on the Pain Matcher as soon as they felt an electrical impulse; this measured DT. The procedure was repeated three times. In the second part of the assessment the subjects were instructed to hold the Pain Matcher as long as possible to measure PE; the procedure was repeated. The mean of the three assessments was used in the statistical analysis. These measuring procedures were performed before the first flotation tank treatment, and also after the last treatment session.

Stress and energy: The stress and energy (SE) instrument measures individuals' energy and stress experiences through self-estimation (28). It consists of two subscales that elucidate the mood levels of the subjects on the dimensions 'experienced stress' and 'experienced energy'. The response options were arranged on six-point scales, extending from 0 (not at all) to 5 (very much). The instrument has been validated by analyses from studies focused on occupational burdens and pressures, and has test-retest scores of 0.73 to 0.78 (28). This instrument was presented both before and after the treatment period.

Hospital Anxiety and Depression scale: The Hospital Anxiety and Depression (HAD) scale rates degree of anxiety and depression. It was constructed by Zigmond and Snaith (29) for use with physically ill people. It has since been revised to be used as a rating scale for anxiety and depression (30). The instrument consists of 14 statements with four response options (ie, 0 to 3) ranging from positive to negative or vice versa. There are seven statements regarding anxiety and seven regarding depression. The HAD scale was completed before and after the treatments.

Procedure

The participants were recruited from patients on the waiting list for participation in the flotation-REST treatment at the Human Performance Laboratory. They were either originally referred by their physicians or had responded to announcements for individuals suffering from localized muscle tension pain in the neck and shoulder area, with or without temporal headache, associated with myofascial tender points or trigger points. Participants were randomly assigned to one of three different experimental studies that included flotation-REST groups with assessments before and after treatment during 12 or more sessions – study 1 (13), study 2 (20) and study 3 (31).

The present study is a secondary analysis based on groups of participants in the aforementioned studies who had participated in one condition (ie, flotation) for 12 sessions, thus yielding 88 participants – 69 women and 19 men. In study 3, one group of participants performed 33 treatments, but the data included in the present study were assessed after their 12 sessions during the first seven weeks (the impact of the remaining 21 treatments was not considered here). Participants in studies 1 and 2 were all treated 12 times over seven weeks. All three studies were approved by the Ethical Board on Experimentation on Human Subjects; all participants provided informed and voluntary consent to participate.

Each participant's first contact with the project was an interview with a pain specialist at the initial medical examination, in which they were informed about the project, screened for suitability using questionnaire 1, completed the different tests (PAI, SE and the HAD scale), and were assessed for their DT and PE. They also underwent a medical examination and a careful pain analysis, including palpation of muscle tone and a neurological examination. Exclusion criteria included pregnancy or ongoing breast feeding, somatic diseases requiring other types of treatment, open wounds, manifest psychiatric symptoms, manifest post-traumatic stress disorder, as well as regular treatment with opioid analgesics, and signs of anxiety and fear or discomfort from being in a restricted environment.

Following this, participants were given flotation treatment during two three-week periods (with two visits per week), whereby each floating session was 45 min long (ie, 12 sessions). Three days (or 72 h) after the final treatment session, participants attended a final consultation and follow-up discussion, at which time they completed questionnaire 2, the different tests (PAI, SE and the HAD scale) and a final assessment of DT and PE. All the participants described in the present study completed the whole course of treatment.

RESULTS

Pain measurements

A two-way mixed Pillai's multivariate ANOVA was performed with sex (men, women) as the between-subjects factor and treatment (before, after) as the within-subjects factor. Variables measuring subjective pain (ie, DT, PE, the PAI and pain frequency) were the dependent variables. The analysis yielded significant effects for sex ($P<0.001$, $Eta^2=0.50$, power > 0.99) and for treatment ($P<0.001$, $Eta^2=0.39$, power > 0.99), but there was no significant sex × treatment interaction effect ($P=0.197$, $Eta^2=0.08$, power = 0.46). The results from the univariate F tests concerning sex and treatment are given below. For means and SDs, see Table 1.

DT: There was a significant effect in regard to sex for DT ($F[1, 75]=5.89$, $P=0.018$). Women were more sensitive in detecting sensations. There was no significant effect of treatment ($P=0.294$) on DT.

PE: There was a significant effect related to sex ($F[1, 75]=72.46$, $P<0.001$). The descriptive analysis showed that the men endured more pain, both before and after treatment, compared

TABLE 1
Detection threshold, pain endurance, pain area inventory (PAI) and pain frequency in regard to sex before (1) and after (2) treatment

	Sex		
Variable	Men	Women	Treatment (all)
Detection threshold 1	5.58±0.51	5.53±4.23*	5.54±3.74
Detection threshold 2	5.47±0.96	4.71±1.20*	4.88±1.19
Pain endurance 1	71.89±32.69	29.90±23.05*	39.17±30.76
Pain endurance 2	79.68±27.30	31.58±21.91*	42.33±30.62†
PAI 1	136.11±177.37	139.38±145.93	138.67±152.17
PAI 2	93.12±119.83	65.45±72.02	71.41±84.46†
Pain frequency 1	4.16±0.60	3.77±0.81	3.85±0.78
Pain frequency 2	3.74±0.93	3.6±1.16	3.63±1.11†

*Data presented as mean ± SD. *Significant effects for sex (P<0.05) in the 'women' condition (before and after); †Significant effects for treatment (P<0.05) in the 'after' condition*

with the women. Furthermore, a univariate F test indicated a significant effect for treatment (F[1, 75]=7.13, P=0.009), which indicated that both men and women enhanced their capacity to endure pain.

PAI: A univariate F test did not indicate a significant sex difference in regard to PAI (P=0.632), but the analyses yielded a significant difference for treatment (F[1, 75]=18.61, P<0.001). Descriptive analysis showed that pain assessed with the PAI was reduced for both sexes after the flotation sessions.

Pain frequency: There was no significant effect for pain frequency in regard to sex (P=0.392). The analyses yielded a significant difference for treatment (F[1, 75]=10.11, P=0.002), and a descriptive analysis showed that the pain frequency decreased for both sexes after the flotation sessions.

Stress-related psychological variables

A two-way mixed Pillai's multivariate ANOVA was performed with sex (men, women) as the between-subjects factor and treatment (before, after) as the within-subjects factor. Dependent variables were the psychological variables; ie, stress (SE), energy (SE), anxiety (HAD scale) and depression (HAD scale), and sleep quality (visual analogue scale). The analysis yielded significant effects for sex (P=0.002, Eta^2=0.21, power = 0.94) and treatment (P<0.001, Eta^2=0.45, power > 0.99), as well as a significant sex × treatment interaction effect (P=0.018, Eta^2=0.16, power = 0.83). The results from the univariate F tests concerning sex, treatment and the sex × treatment interaction are given below. For means and SDs, see Table 2.

Stress: The analyses yielded a significant difference for treatment (F[1, 83]=24.70, P<0.001), and a descriptive analysis showed that stress was reduced after the flotation sessions. There was also a significant sex × treatment effect (F[1, 83]=4.55, P=0.036) in which the womens' stress levels decreased more than the mens' levels. The analysis indicated no significant effect for sex (P=0.478).

Energy: The analyses yielded no significant effects for energy (all P>0.05).

Anxiety: The analyses yielded a significant difference for treatment (F[1, 83]=43.16, P<0.001), and a descriptive analysis showed that anxiety was reduced after the flotation sessions. There were no other significant effects (all P>0.05).

Depression: The analyses yielded a significant difference for sex (F[1, 83]=5.31, P=0.024), and a descriptive analysis showed

TABLE 2
Stress, energy, anxiety, depression and sleep quality in regard to sex before (1) and after (2) treatment

	Sex		
Variable	Men	Women	Treatment (all)
Stress 1	2.04±1.11	2.47±0.92	2.37±0.97
Stress 2	1.69±1.04	1.60±1.03‡	1.62±1.02†
Energy 1	2.78±0.70	3.06±0.90	3.00±0.86
Energy 2	2.97±0.69	2.97±0.76	2.97±0.74
Anxiety 1	7.42±2.83	8.36±4.17	8.16±3.92
Anxiety 2	5.84±4.00	5.99±3.30	5.96±3.44†
Depression 1	3.37±3.29	6.74±4.60*	6.01±4.55
Depression 2	3.42±3.25	4.19±3.21‡	4.03±3.21†
Sleep quality 1	39.31±22.87	45.48±21.21	44.15±21.51
Sleep quality 2	44.68±26.75	54.25±26.49	52.16±26.67†

*Data presented as mean ± SD. *Significant effects for sex (P<0.05) in the 'women' condition (before and after); †Significant effects for treatment (P<0.05) in the 'after' condition; ‡Significant interaction effects for sex × treatment (P<0.05) in the 'women' and 'after' conditions*

that the women were more depressed than the men. In addition, there was a significant difference for treatment (F[1, 83]=11.94, P=0.001), and a descriptive analysis showed that depression diminished after the flotation sessions. Finally, there was also a significant sex × treatment interaction effect (F[1, 83]=12.97, P=0.001), and further analysis (paired samples *t* tests, 5% level) showed that there was no significant difference in regard to levels of depression before and after the flotation sessions for the men, but there was such a significant effect for the women. An independent samples *t* test (5% level) showed that there was a significant difference between men and women before treatment, but there was no difference after treatment.

Sleep quality: The analyses yielded a significant difference for treatment (F[1, 83]=9.30, P=0.003), and a descriptive analysis showed that sleep quality was enhanced after the flotation sessions. There were no other significant effects (all P>0.05).

DISCUSSION

The aim of the present study was to explore possible sex differences among patients diagnosed with stress-related pain before and after flotation-REST treatment. The analyses showed that the flotation-REST treatment had beneficial effects on stress, anxiety, depression and stress-related pain – findings that are in line with those of several other studies (11,13). The results regarding sex differences were somewhat more varied, although our main impression was that there were relatively few sex differences. Men and women perceived the extent and frequency of their pain similarly before and after the treatment, and both sexes reported improvement due to flotation-REST. Similar findings were obtained with regard to anxiety and sleep quality. There were no significant sex or treatment differences regarding energy. There were, however, sex differences in regard to depression, suggesting that women, compared with men, displayed higher depression scores before the flotation-REST treatment. The women improved more in terms of depression scores due to the treatment and then achieved the same levels as the men.

There was a sex difference regarding DT, suggesting that women registered stimulation from the Pain Matcher instrument at lower levels than the men, a finding that is in line with

previous studies (23). The flotation-REST treatment did not affect the DT in either women or men.

With regard to PE, there was also a sex difference, indicating that men displayed greater persistence in enduring pain generated by the Pain Matcher both before and after the flotation-REST treatment – a finding that supports the results of a previous analysis (11). For the first time, it was shown that both sexes improved their ability to endure pain (ie, higher PE scores) following successful treatment. This result indicates that enhanced PE may constitute a marker for normalization to a more pain-free state given successful treatment. Enhanced electrical PTs after successful pain treatment have previously been documented (32), as have lowered PTs in patients with pain (32-34).

There have been discussions of whether the observed difference between men and women in regard to different thresholds (ie, DT, PT and upper threshold) represents sex differences in the pain experience or differences in the expressions of how pain is reported (25). Pain perception in women varies with the menstrual cycle and during pregnancies (35,36). In the current study, we aspired to create conditions as similar as possible in the above regard by conducting the treatment with flotation-REST with both sexes during two three-week periods consisting of two treatments per week for three weeks, followed by a week without treatment. This design made it possible for the female subjects to plan the timing of their flotation treatments around their menstrual cycle.

During measurement of DT and PE, the participants held a highly reliable instrument (Pain Matcher) that generated an increasing electrical stimuli in their hand. They were to report the stimuli as soon as they were detected (DT) and to endure the pain as long as possible during the experience of increasing pain (PE). This instrument offers a straightforward objective measurement of the detected or endured intensity, and no subjective evaluations (eg, a visual analogue scale) were performed. However, more research is needed before the question may be settled of whether sex differences in regard to pain experience represent actual sex differences or differences in how pain is reported.

As mentioned above, the current study is the first to compare men and women undergoing flotation-REST treatment. One reason for conducting such a study is the fact that female patients are over-represented among patients with burnout depression, fibromyalgia, disorders related to whiplash and other stress-related ailments. Of the patients who make appointments at the stress clinic of the Human Performance Laboratory, 80% are women. The results of the present study suggest that both men and women may be recommended for flotation-REST therapy. The results also indicate that enhanced PE may constitute an additional marker, over and above subjective measures, for the effectiveness of the method.

AUTHOR'S NOTE: The studies included were all approved by the Ethical Board on Experimentation on Human Subjects (Forskningsetikkommittén) at Örebro Academic Hospital, Örebro, Sweden.

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