
Effects of flotation-REST on muscle tension pain

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A Kjellgren, U Sundequist, T Norlander, T Archer.
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Pain Res Manage 2001;6(4):181-189.

The purpose of the present study was to investigate whether the floating form of the restricted environmental stimulation technique (REST) may be applied within the field of pain relief. Flotation-REST consists of a procedure whereby an individual is immersed in a tank filled with water of an extremely high salt concentration. Thirty-seven patients (14 men and 23 women) suffering from chronic pain consisting of aching muscles in the neck and back area participated in the study. They were randomly assigned to either a control group (17 participants) or an experimental group (20 participants). The experimental group received nine opportunities to use the flotation-REST technique in the water tank over a three-week period. The results indicated that the most severe perceived pain intensity was significantly reduced, whereas low perceived pain intensity was not influenced by the floating technique. Further, the results indicated that circulating levels of the noradrenaline metabolite 3-methoxy-4-hydroxyphenylethyleneglycol were reduced significantly in the experimental group but not in the control group following treatment, whereas endorphin levels were not affected by flotation. Flotation-REST treatment also elevated the participants' optimism and reduced the degree of anxiety or depression; at night-time, patients who underwent flotation fell asleep more easily. The present findings describe possible changes, for the better, in patients presenting with chronic pain complaints.

Key Words: *Altered state of consciousness; Anxiety; Depression; Flotation; Life orientation test; Pain reduction; Restricted environmental stimulation technique*

Effets d'une technique de restriction des stimuli environnementaux et de flottement sur la douleur d'origine musculaire

RÉSUMÉ: Le but de la présente étude était de vérifier si le volet flottement d'une technique de restriction des stimuli environnementaux (technique REST pour *restricted environmental stimulation technique*) peut s'appliquer au domaine de l'analgésie. La technique de flottement-REST consiste à immerger le sujet dans un réservoir rempli d'eau à teneur extrêmement forte en sel. Trente-sept patients (14 hommes et 23 femmes) souffrant de douleurs chroniques, soit de douleurs musculaires au cou et au dos, ont pris part à l'étude. Ils ont été assignés aléatoirement soit à un groupe témoin (17 patients) ou à un groupe expérimental (20 patients). Le groupe expérimental a reçu neuf occasions d'utiliser la technique de flottement-REST dans un réservoir d'eau au cours d'une période de trois semaines. Selon les résultats enregistrés, l'intensité douloureuse la plus grave perçue a été significativement atténuée, alors que l'intensité douloureuse la plus faible perçue n'a subi aucune influence de la technique de flottement. En outre, les résultats ont montré que les taux du métabolite circulant 3-méthoxy-4-hydroxyphényléthylène-glycol de la noradrénaline était significativement diminué dans le groupe expérimental et non dans le groupe témoin après le traitement, alors que les taux d'endorphine n'ont subi aucune influence de la technique de flottement. Le traitement par flottement-REST a en outre stimulé l'optimisme des participants et réduit leur degré d'anxiété ou de dépression. Au coucher, les patients soumis au traitement de flottement se sont endormis plus facilement. Ces résultats décrivent certaines améliorations possibles chez les patients qui souffrent de douleurs chroniques.

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Received for publication June 9, 2000. Accepted November 29, 2000

The current achievement-based, demanding, high tempo society has incurred increased risks and vulnerability for stress-related chronic pain and other illnesses. Increased muscle tension facilitates the development of chronic pain, and has been observed to induce negative effects on concentration, self-confidence, learning and memory. The brain and central nervous system undergo constant bombardment with information. Relaxation exercises offer a means of reducing the physiological and psychological reactions to stress; however, the individuals most in need of relaxation techniques are often those who find it most difficult to perform these exercises (1,2).

The flotation-restricted environmental stimulation technique (REST) is a method whereby an individual is placed in a horizontally floating posture, immersed in high-concentration salt water, in an environment (the floating tank) where all incoming stimuli are reduced to the minimum during a short period. The salt water in the floating tank is maintained at skin temperature, ear-plugs are used to minimize sounds, and when the tank is closed complete darkness ensues. Flotation-REST is cost effective and secure, with minimal or complete absence of adverse effects (3,4). The method was developed by Lilly (5) in the 1950s, and no accidents or mishaps have been reported with its use. Previous reports concerning stimulus-reduction to the sensory organs (sensory deprivation) indicated several negative effects, such as confusion, worry and stress (6), whereas more recent research has shown that meaningful, positive effects may be obtained (7). However, several studies have demonstrated positive effects, such as increased well-being (8); mild euphoria (7); increased originality (9); improved sleep (10); reduced stress, tension and anxiety (4,7,11); reduced blood pressure (11,12); and less muscle tension (13). The technique has also been shown to be a suitable complement to psychotherapy (8,14). The experience is pleasant, and subjects always endorse it on further occasions (15).

Several studies have applied flotation-REST as a method of alleviating different types of pain conditions. Patients suffering from chronic headache experienced significant improvements after flotation-REST treatment, and these improvements were maintained during follow-up six months later (16). Notable improvements in patients with rheumatic aches were observed by Mereday et al (17). Alleviation of premenstrual pain was noted by Goldstein and Jessen (18). Other studies showing analgesic effects associated with flotation-REST have been reported by Fine and Turner (19), and Norlander et al (15). Attempts have been made to identify the physiological markers for the subjectively experienced pain alleviation that is often reported with flotation-REST. Significant reductions in adrenocorticotrophic hormone and plasma cortisol levels have been found after REST (20,21). One study (12) showed, in a series of eight sessions, that REST was followed by a decrease in plasma cortisol levels and a reduction in arterial blood pressure compared with the initial treatment. However, Schulz and Kaspar (7) did not find any changes in

plasma cortisol levels and other endogenous substances in subjects 60 min after floating compared with lying on a mattress for an equivalent period of time.

Flotation-REST is a technique that readily induces a state of altered consciousness (22). This condition has been described as a cognitive shift to the advantage of primary process-oriented cognition (2,23). More logical thinking and directed attention (secondary process) are shunted aside by more intuitive thinking and nondirected fantasy (primary process). To apply flotation-REST as a treatment or therapy, it is essential that the personnel involved have sufficient knowledge of the conditions being treated. The degree to which a person experiences an 'altered state' is highly individual. The most usual experience is likely one of calm and pleasant relaxation, often in combination with a somewhat altered perception of time (24). Other individuals experience, over and above this relaxation, a dream-like or hypnotic state (15), wherein slight perceptual or cognitive alterations may occur. Visual phenomena, ranging from spots, colours and lights to lively spontaneous images (unwilled vivid imagery) have been described by Forgaes and Belinson (24), and Raab and Gruzelier (25). Lilly (5) accumulated a comprehensive literature on mental experiences in the floating tank. Norlander et al (15) reported that flotation-REST can induce intense transpersonal experiences that generally occur with altered states of consciousness, despite the type of induction, but are perhaps strongest in drug-induced states (26,27).

The purpose of the present study was to investigate whether flotation-REST is an effective and reliable method for treating chronic pain, as well as several psychosomatic symptoms resulting from long term muscle tension and/or stress-related headaches.

SUBJECTS AND METHODS

Participants

A portion of the participants were recruited through a 'remission' procedure (a procedure that allows patients access to specialized treatment on recommendation from their physician) from each one's general practitioner. A portion of the participants responded to announcements by the Karlstad University, Sweden, for individuals suffering from localized muscle tension pain in the neck and shoulder area, with or without temporal headache, associated with myofascial tender points (28) or trigger points (29,30). Each individual was required to make an initial visit to the clinic, where he or she was informed about the project, was screened for suitability, and underwent a medical examination and a careful pain analysis, including palpation of muscle status and neurological examination. Among the exclusion criteria were pregnancy or ongoing breastfeeding, somatic problems or illnesses requiring other types of treatment, open wounds, manifest psychiatric symptoms, neurological disturbances, whiplash-related disorders, manifest post-traumatic stress disorder, regular treatment with opiate analgetics or sedatives, and signs of anxiety, fear or discomfort due to enclosure in a restricted environment. The 44

subjects were randomly assigned to either the control group or the experimental group. Five subjects in the experimental group and two subjects in the control group withdrew from the experiment. Therefore, the final experimental population consisted of 37 subjects comprising a control group (17 subjects – seven men and 10 women) and an experimental group (20 subjects – seven men and 13 women). The mean age of the participants was 31.63 years ($SD=9.87$). Approximately half of the participants (56.75%; 21 patients) presented with more than one type of pain complaint, and almost the same number (51.36%; 19 subjects) reported that the onset of pain had been immediate. One subject (2.7%) reported that the pain had begun in association with an illness (infection); seven subjects (18.92%) indicated that ‘accidents’ (fall) were the cause of the pain. Other causes named were ‘postoperative’ (two subjects; 5.41%) and ‘postphysical abuse’ (one subject; 2.7%), but the majority of subjects reported the common causes of myofascial pain, such as monotonous, repeated physical strain or high demands. The participants’ earlier experiences of pain treatment consisted of such methods as analgesics (paracetamol, nonsteroidal anti-inflammatory drugs, opioids), physiotherapy and acupuncture, the relative frequencies of which are presented in Table 1. Approximately one-third of the participants (14 subjects; 37.84%) reported that they were taking an occasional paracetamol medication (maximum 4000 mg during the three weeks) or ibuprofen (one subject with a total of 1200 mg) during the course of the experiment; these participants were from both the control and experimental groups. The subjects did not receive any other type of medication treatment during the study period. Sleep disturbances were reported by seven subjects (18.92%; three control and four experimental). None of the patients were receiving any other form of treatment (eg, physiotherapy) during the study period. This stipulation was ensured contractually and was monitored throughout the study.

The total frequencies of the reported health-related problems (eg, allergies, constipations, heart-flutters, neurological deficiencies, breathing problems) were summated (according to the information acquired at the initial medical examination) to measure the ‘total burden’. A two-way ANOVA with sex and groups as independent variables did not show any significant differences between the groups or any effect of the interaction ($P>0.67$). However, there was a significant effect of sex ($F[1,42]=10.90$; $P=0.002$), whereby the female subjects (5.63 ± 1.24 [mean \pm SD]) had encountered a larger number of complaints than the male subjects (3.13 ± 1.25).

Statistical analysis through application of two-way ANOVA with group and sex as independent variables did not show any significant differences between groups with regard to blood pressure, age, anxiety and depression scales (Hospital Anxiety Depression Scale [HAD]), degree of dispositional optimism (life orientation test [LOT]), cigarette and alcohol consumption, and self-estimations of the most severe pain and normal pain, respectively ($P>0.12$).

TABLE 1
Incidence of previous treatment for chronic pain

Method	n (%)
Analgesics	20 (54.05)
Other medications	7 (18.92)
Physiotherapist	29 (78.38)
Surgical/orthopedic treatment	2 (5.41)
Acupuncture	12 (32.43)
Transcutaneous electrical nerve stimulation	4 (10.81)
Relaxation training	15 (40.54)
Other treatments	19 (51.35)

However, there was a significant difference ($F[1,42]=6.89$; $P=0.012$) between groups with regard to how long (number of months) the pains had persisted, whereby the control group had experienced pain during a shorter period (41.03 ± 38.68) than the experimental group (67.58 ± 58.17); it should be noted that longer durations of chronic pain may have affected the pain sensitivity of the patients, but whether this affects receptivity for the flotation treatment remains to be resolved. A significant effect of sex was found for anxiety ($F[1,44]=7.702$; $P=0.008$), whereby the men had lower values for anxiety (5.94 ± 2.82) than women (8.93 ± 3.75). No other significant differences were obtained with regard to group and sex. Nor did Mann-Whitney U-tests show any group or sex effects with regard to the use of analgesics, other forms of therapy or how long the pain symptoms had persisted ($P>0.10$).

Design

The case history of the recruited participants was taken by the physician (a senior physician in pain management) to assess the status of the pain symptoms (using a combined interview and questionnaire technique) and judge whether each subject was free of exclusion criteria. Blood samples were taken at that time. Subjects were then randomly assigned to the control or experimental groups. Subjects in the experimental group participated in a total of nine treatments (three times per week during three weeks). Each flotation treatment lasted 45 min, resulting in a total of 300 h of treatment. In addition to these treatments, each participant was required to complete different types of questionnaires. After the last flotation treatment, a second medical examination was made, incorporating new blood samples and a follow-up of the assessment of pain status. The control group was required to leave blood samples and complete the initial questionnaires without flotation or any other treatment and then returned for a further blood sampling and examination of pain status after the identical three-week period.

Instruments

Flotation tank: The flotation tank (Flytarium Norden AB, Sweden) measured $2620\times 1670\times 950$ mm. The depth of fluid (salt water) varied between 200 and 300 mm. The flotation

tank was insulated to maintain a constant air and water temperature, and to reduce incoming light and noise. The water temperature was maintained at 34.4°C and was saturated with magnesium sulphate (density 1.3 g/cm³). The tank was equipped with a horizontal entrance that was easy to open and close (from inside and out) by the subject. Between flotations, a hydrogen peroxide solution was added regularly, followed by filtration of the salt water and sterilization with ultraviolet light. The number and duration of treatments, ie, nine over a three-week period, were chosen from similar schedules described in the literature. Another reason for maintaining a three-week duration was that female subjects participating could plan the timing of their flotation treatments around the incidence of each menstrual cycle. Blood sampling for women in the control group was scheduled in the same manner.

Questionnaire 1: At the initial medical examination, the participants were given a form to estimate self-assessed pain severity, duration, onset and treatment, as well as experiences and symptoms of other types of complaints. Information regarding sleep, dreams, tobacco and alcohol habits was also collected. Each subject's own descriptions of 'severest pain intensity' and 'normal pain intensity', respectively, were estimated on visual analogue scales (0 to 100).

Questionnaire 2: Questionnaire 1 was given again at the final medical examination, after three weeks of the experimental flotation procedure.

HAD: The validity and reliability of the HAD scale for assessing degree of anxiety and depression symptoms were examined by Herrmann (31). The HAD scale measures the degree of anxiety and depression, wherein values under 6 are considered normal, those between 6 and 10 are borderline, and all values over 10 points are indicative of a probable depression-anxiety diagnosis.

LOT: The LOT test (32) consists of eight items, plus four filler items. The task of each participant is to decide whether one is in agreement with each of the items described, on a scale of 0 to 4, where 0 indicates 'strongly disagree' and 4 indicates 'strongly agree'. The test measures dispositional optimism, defined in terms of generalized outcome expectancies. Parallel test reliability is reported to 0.76 and internal consistency to 0.76 (32). LOT is also regarded to have an adequate level of convergent and discriminant validity (32), demonstrated by correlation statistics and by using LISREL VI ($r=0.64$).

Subjective flotation experience: Each subject was given a questionnaire (15) to determine whether the flotation was experienced as pleasant, whether the subject experienced fear or anxiety during flotation, and whether the subject was willing to float again. These responses were estimated on a visual analogue scale (0 to 100). The severe flotation experience (SFE) form was applied directly after the first occasion of flotation to evaluate how much each of the participants 'enjoyed' the treatment. The dependent variable measured (visual analogue scale 0 to 100) 'how pleasant was it to float?', 'how intensive was the experienced fear?' and 'to what extent would you like to float again?'

Experienced deviation from the normal state: Using the internationally applied psychometric instruments, the APZ questionnaire and the OAVAV (6), for obtaining judgements of altered states of consciousness, a shortened but similar instrument modified for use with flotation-REST was applied. The APZ and OAVAV forms are the internationally applied standard for this purpose, and these tests have been validated in several studies over different countries (33). Because the test forms were originally intended for the study of altered states of consciousness as induced by hallucinogenic substances, a number of the original questions were not relevant when flotation-REST was applied as the method of induction. In total, the 'experienced deviation from the normal state' (EDN) consists of 29 questions, with responses marked on a visual analogue scale (0 to 100). The major portion of these data are not applicable to the present study, so only a part of the test results are presented here. A complete 'index of experience' was constructed from the points obtained from all 29 questions and were summated to provide a 'sum of experience'. These values should reflect the total EDN.

Analysis of blood samples: The blood samples taken from each subject were analyzed with regard to beta-endorphin and 3-methoxy-4-hydroxyphenylethyleneglycol (MHPG), the major metabolic product of noradrenaline, neurotransmitter and hormone released under stress conditions. Opioid peptide levels were determined by the radioimmunoassay method described by Brammert et al (34). MHPG was measured with high-performance liquid chromatography using electrochemical detection described by Scheinin et al (35).

Procedure

Participants experiencing pain, tension or headache were recruited through noticeboard announcements at the Karlstad University, Sweden. Some participants were recruited through the 'remission' procedure (see above) from their corporate or institutional health boards, as well as from general practitioners, to take part in the project. Each subject's first contact with the project was during the interview with the general practitioner at the initial medical examination where the current status of pain complaints was established through the application of questionnaire 1. During this interview, each participant's degree of anxiety-depression was assessed using HAD to exclude individuals with excessively high degrees of anxiety or depression. After this, LOT was completed. Then, a blood sample was taken for later analysis of beta-endorphin and MHPG. Every participant received a leaflet with patient-oriented information about flotation-REST, wherein, in addition to being provided with the purely practical details associated with treatment, they were informed that driving was not recommended shortly after treatment (due to increased risk of transient tiredness). During this initial contact, each subject was shown around the floatarium, and participants were told that those assigned to the control group would also receive flotation treatment. The information was strict (no mentioning of possible changes in consciousness), and the partici-

pants were only informed that most people find the floating to be relaxing. Following this orientation, participants were randomly assigned to either the control group or the experimental group. Subjects in the control group were followed up after three weeks with a new medical examination, where they also completed questionnaire 2, HAD and LOT, and gave a second blood sample. Subjects in the experimental group underwent flotation treatment during the forthcoming three periods (with three visits per week); each floating session was of 45 min duration. The experiment was carried out over four months at the flotation-REST laboratory, Karlstad University. Group assignments were made by the project leader and the resident physician. The project leader never met any of the patients, and the resident physician never met the patients in the context of flotation. The experimenters at the flotation site were ignorant of the group identity of each participant and thus, to all purposes, experimentally blind. A 'spontaneous randomization' process consisting of a 'first come, first assigned' method was applied. When the subjects were using the flotation tank on the very first session, they were informed of the floating technique, shown the toilet and shower, and reminded that they were free to terminate the session whenever they wanted. After visiting the toilet, showering and inserting the earplugs, each subject was allowed to immerse his- or herself into the tank and close the entrance of the tank unaided, after having been instructed to relax. Treatment was terminated after 45 min when the experimenter gently knocked on the wall of the tank. Once the subject had emerged, showered and changed clothes, he or she was required to complete the SFE. An identical routine was maintained at each succeeding treatment session. After the second flotation session, each subject was required to complete the EDN. Three days (or 72 h) after the final treatment session, a new blood sample was taken when subjects met the general practitioner for the second medical examination and follow-up discussions, at which time they completed questionnaire 2, HAD and LOT using the same procedure as for the control group. All the patients described in the present study completed the entire course of treatment (ie, nine sessions over three weeks). However, patients who abandoned the treatment program were excluded at once and are described as such above.

RESULTS

The dependent variables concerning both experimental groups were analyzed with three-way split-plot ANOVAs, with effects before and after treatment as the within-subject factor, and group and sex as the between-subjects factors. Three-way split-plot ANCOVAs with beta-endorphin concentrations before treatments as the covariate, and before and after treatment as the within-subject factor (ie, MHPG, pain intensity at its worst, 'normal' pain intensity, dispositional optimism, depression, anxiety, number of hours of sleep per night, time to sleep onset, experience of sleep quality and blood pressure) were used to examine the extent that beta-endorphin concentrations before treatments influ-

TABLE 2

Beta-endorphin (END), 3-methoxy-4-hydroxyphenyl-ethyleneglycol (MHPG), severe pain (SPAIN), normal pain (NPAIN), dispositional optimism (LOT), depression (DEP), anxiety (ANX), and falling asleep time (FASLP) before (-1) and after (-2) treatment with regard to group (control, restricted environmental stimulation technique [REST])

	Control	REST	Total
END-1 (pmol/L)	34.00±7.45	27.83±5.61	30.83±7.18
END-2 (pmol/L)	33.53±6.36	30.00±6.10	31.71±6.39
MHPG-1 (nmol/L)	10.18±2.74	10.83±4.22	10.51±3.54
MHPG-2 (nmol/L)	10.12±2.78	8.94±1.80*	9.51±2.37
SPAIN-1 (VAS)	59.06±17.68	61.75±18.78	60.51±18.08
SPAIN-2 (VAS)	60.41±17.21	37.25±30.22*	47.89±27.40
NPAIN-1 (VAS)	16.53±8.74	12.65±12.16	14.43±10.76
NPAIN-2 (VAS)	25.06±16.44*	12.20±14.55	18.11±16.55
LOT-1 (points)	21.88±6.22	22.25±5.42	22.08±5.72
LOT-2 (points)	22.76±6.07	24.95±5.22*	23.95±5.65
DEP-1 (points)	3.53±2.94	3.40±2.91	3.46±2.88
DEP-2 (points)	3.47±2.85	2.25±2.20*	2.81±2.56
ANX-1 (points)	7.94±3.65	7.50±3.32	7.70±3.43
ANX-2 (points)	8.18±4.53	4.95±4.11*	6.43±4.55
FASLP-1 (min)	19.21±15.15	13.98±13.66	16.38±14.40
FASLP-2 (min)	16.06±11.48	8.42±7.86*	12.03±10.34

Values are means ± SD. VAS Visual analogue scale. *Significant difference between before and after treatment

enced the results. The analyses did not yield any significant effects other than those obtained through the ANOVAs, which indicated that the difference between the groups with regard to beta-endorphin concentrations did not influence the above-mentioned within-subject factors. For means and standard deviations see Table 2.

Analysis of blood samples

Beta-endorphins: There were no significant differences in beta-endorphin concentrations before and after treatments, or between the sexes ($P>0.1$), but higher beta-endorphin concentrations were found in the control group than in the experimental group ($F[1,31]=4.41$; $\text{Eta}^2=0.13$; $P=0.044$).

MHPG: There was a significant difference in MHPG concentrations before and after treatments ($F[1,31]=4.99$; $\text{Eta}^2=0.14$, $P=0.033$), whereby MHPG concentrations were lower after treatment than before. There was a significant interaction effect between MHPG concentrations and group before and after treatments ($F[1,33]=4.19$, $\text{Eta}^2=0.12$, $P=0.049$). Analysis of interaction (paired samples t test, 5% level) indicated that the experimental group had lower concentrations of MHPG after treatment than before. There were no differences obtained before and after treatment for the control group. No other interaction effects were obtained, nor were there any other differences with regard to group or sex ($P>0.15$).

Experience of pain intensity

Pain intensity at its worst: The analysis indicated that there was a significant difference in experienced 'worst pain' before and after treatment ($F[1,33]=6.90$; $\text{Eta}^2=0.17$; $P=0.013$), whereby pain was experienced as being more severe before treatment than after. There was a significant correlation between group and pain before and after treatment ($F[1,33]=9.82$; $\text{Eta}^2=0.23$, $P=0.004$). Analysis of interaction (paired samples *t* test, 5% level) indicated that the experimental group experienced less severe pain after treatment than before treatment. This was not the case for the control group. There were no other interaction effects, and no differences with regard to sex ($P>0.25$).

'Normal' pain intensity: The analysis indicated a significant difference in experienced 'normal pain' before and after treatment ($F[1,33]=5.15$; $\text{Eta}^2=0.14$, $P=0.030$), with pain being less intense before the treatment period than after. There was a significant correlation between group and 'normal' pain before and after treatments ($F[1,33]=5.04$; $\text{Eta}^2=0.13$; $P=0.032$), whereby interaction analysis (paired samples *t* test, 5% level) indicated that the control group experienced more pain after the treatment period than before. In the experimental group, no significant differences before and after treatment were found. No other interaction effects were obtained, nor were any sex differences evident ($P>0.41$).

Personality traits

Dispositional optimism: The personality trait dispositional optimism was measured with the LOT-test. Results indicated a significant change in optimism from before to after treatment ($F[1,32]=18.08$; $\text{Eta}^2=0.37$, $P=0.001$), with degree of optimism increasing after treatment. There was a significant correlation between group and optimism before and after treatments ($F[1,32]=5.755$; $\text{Eta}^2=0.16$; $P=0.022$), where analysis of interaction (paired samples *t* test, 5% level) showed that the experimental group had a higher degree of optimism after treatment than before treatment; no difference between before and after treatment was seen in the control group. No other significant differences with regard to group and sex, or interaction effects were obtained ($P>0.2$).

Depression: The results indicated that there was a significant difference in depression assessment before and after treatment ($F[1,32]=5.51$; $\text{Eta}^2=0.13$; $P=0.025$); the degree of depression was reduced after treatment. There was a significant correlation between groups and degree of depression before and after treatments ($F[1,32]=5.04$; $\text{Eta}^2=0.12$; $P=0.032$). Interaction analysis (paired samples *t* test, 5% level) showed that the experimental group had a lower degree of depression after treatment than before treatment. There were no such differences in the control group. No other results were significant ($P>0.50$).

Anxiety: The analysis indicated that there was a significant difference in anxiety before and after treatment ($F[1,33]=6.88$; $\text{Eta}^2=0.17$; $P=0.013$); level of anxiety decreased after treatment. There was a significant correla-

tion between groups, and level of anxiety before and after treatments ($F[1,33]=9.87$; $\text{Eta}^2=0.23$; $P=0.04$). Interaction analysis (paired samples *t* test, 5% level) showed that the experimental group had a lower level of anxiety after treatment than before treatment; no such differences were seen for the control group. No other significant results were obtained ($P>0.11$).

Sleep

Number of hours of sleep per night: Participants were required to indicate their duration of sleep before and after treatment. There were no significant differences or correlations ($P>0.10$).

Time to sleep onset: There was a significant difference in time to sleep onset before and after treatment ($F[1,32]=4.71$; $\text{Eta}^2=0.20$, $P=0.038$). Time to sleep onset was shorter after treatment than before treatment. There was a significant correlation between time (minutes awake) and sleep onset before and after treatments and group ($F[1,32]=4.71$; $\text{Eta}^2=0.23$; $P=0.038$). Interaction analysis (paired samples *t* test, 5% level) showed that the experimental group fell asleep more quickly after treatment than before treatment; no similar difference was seen in the control group. Finally, there was a group effect ($F[1,32]=4.53$; $\text{Eta}^2=0.17$, $P=0.041$), whereby the experimental group fell asleep more quickly than the control group. No other significant differences were found.

Experience of sleep quality: Participants were required to assess, on the VAS scale (0 to 100), their sleep quality before and after treatment. Analysis did not indicate any significant differences or interactions ($P>0.16$).

Cigarette and alcohol consumption: No significant differences in cigarette or alcohol consumption were found ($P>0.10$).

Blood pressure: A three-way split-plot analysis was used to examine whether the participants' blood pressures were altered during treatment. The within-subjects factor was systolic-diastolic blood pressure, and the between-subjects factors were group and sex. No significant differences or interactions were found ($P>0.10$).

Mental experiences during floating

Global notions about floating: Using the personality inventory provided by the LOT (collected before treatment), the participants were classified as either 'optimists' (more than 23 LOT points) or 'pessimists' (fewer than 22 LOT points). In addition, the participants were classified in a similar manner as 'low anxiety' or 'high anxiety', and 'low depressive' or 'high depressive', from the results of the HAD test. Differences between optimists and pessimists, between low and high anxiety, and between low and high depressive, were analyzed on the SFE scales. One-way ANOVA did not show any difference between optimists and pessimists with respect to fear of floating or the extent to which the subjects would like to float again ($P>0.07$). There was a significant difference in the factor 'how pleasant was it to float?' ($F[1,24]=5.58$; $P=0.027$); optimists experienced

TABLE 3

Correlation analyses (Pearsons' *r*, corrected for the number of comparisons according to Bonferroni) between the most significant dependent variables before treatment: severe pain (SPAIN), normal pain (NPAIN), beta-endorphin (END), 3-methoxy-4-hydroxyphenylethyleneglycol (MHPG), anxiety (ANX), depression (DEP), dispositional optimism (LOT) and falling asleep time (FASLP)

	SPAIN	NPAIN	END	MHPG	ANX	DEP	LOT	FASLP
SPAIN	1.00							
NPAIN	0.34	1.00						
END	0.11	0.29	1.00					
MHPG	-0.17	-0.08	-0.16	1.00				
ANX	0.19	-0.01	-0.18	-0.31	1.00			
DEP	-0.05	0.21	0.05	0.07	0.44*	1.00		
LOT	-0.24	-0.10	0.02	0.07	-0.69**	-0.55**	1.00	
FASLP	-0.04	-0.23	-0.02	0.07	0.35	0.39*	-0.22	1.00

* $P < 0.05$; ** $P < 0.01$

greater enjoyment (80.71 ± 15.01) than the pessimists (61.00 ± 26.34). There was no significant difference between participants with low anxiety and those with high anxiety, or between those who were 'low depressive' and those who were 'high depressive', respectively, regarding their experiences of enjoyment, fear and wanting to float again ($P > 0.11$).

Experience of altered state compared with normal state: EDN forms were used to measure the extent of different types of experiences. Every experience was measured as a deviation from a normal state on a VAS-scale of 0 to 100. Experiences that were most common were: 'feeling of drifting' (68.2 ± 31.88), 'my body feels wonderful' (65.72 ± 26.89), 'a dream-like time and space feeling' (63.97 ± 34.25), 'a feeling of deep peace within me' (54.07 ± 32.51) and 'a feeling of falling asleep' (47.10 ± 37.90). Feelings that occurred least frequently were: 'heard odd words' (2.48 ± 6.40), 'heard tones and clangs' (7.00 ± 14.57), 'saw colours with my eyes closed' (9.41 ± 16.74), 'received insights about previously puzzling occurrences' (10.42 ± 21.13) and 'came to think about things that I'd forgotten long ago' (10.52 ± 19.79). No significant differences (one-way ANOVAs) were seen between optimists and pessimists, between those with low anxiety and those with high anxiety, or between low depressives and high depressives with regard to the summated experience of deviation from a normal state.

Correlations

Correlations (Pearsons' *r*) between the most significant variables before (Table 3) and after (Table 4) were computed.

DISCUSSION

The main finding of the present study was that flotation-REST induced a significant reduction of 'severest' pain intensity, a significant decrease of noradrenaline metabolite, MHPG, values in the blood, a significant reduction of anxiety and depression concomitant with an increase in the

TABLE 4

Correlation analyses (Pearsons' *r*, corrected for the number of comparisons according to Bonferroni) between the most significant dependent variables after treatment: severe pain (SPAIN), normal pain (NPAIN), beta-endorphin (END), 3-methoxy-4-hydroxyphenylethyleneglycol (MHPG), anxiety (ANX), depression (DEP), dispositional optimism (LOT) and falling asleep time (FASLP)

	SPAIN	NPAIN	END	MHPG	ANX	DEP	LOT	FASLP
SPAIN	1.00							
NPAIN	0.55**	1.00						
END	0.41*	0.24	1.00					
MHPG	0.14	0.37	-0.01	1.00				
ANX	0.12	0.30	-0.08	0.27	1.00			
DEP	0.19	0.42*	-0.01	0.23	0.65**	1.00		
LOT	-0.29	-0.28	-0.03	-0.11	-0.74**	-0.71**	1.00	
FASLP	0.22	0.40*	-0.18	0.56**	0.49**	0.39*	-0.30	1.00

* $P < 0.05$; ** $P < 0.01$

degree of dispositional optimism. In addition, a significantly shorter latency to fall asleep at night was noted. The observation that the method was generally experienced as pleasant suggests that flotation-REST should harness a large positive potential for reducing pain and at least some of the effects of chronic, negative stress. It should be noted that several participants had suffered from pain for many years and had been subjected to several types of treatment during that period (Table 1).

A significant effect of pain alleviation was verified only with regard to 'severest experienced pain' on comparison before and after floating treatment, but not for 'normal pain', which may not be obvious or apparent. It is most likely that the flotation-REST technique maintains a primary pain alleviation effect for the experience of severe pain and not for 'normal' pain. However, judging from all the enthusiastic comments derived during the treatment period, other explanations over and above the documented effect should be examined. For example, it is possible that the flotation-REST treatment affects 'worst' pain without altering 'normal' pain. The answer to this dilemma may rest with the patients' experiences of these two types of pain. Recent results (unpublished data) suggest that flotation-REST affects the pain intensity experience of healthy volunteer subjects.

Whether the significantly increased degree of optimism (LOT test) seen in the present study was a consequence of the pain-alleviating effect of the treatment, pleasantness, the feeling of hope and enthusiasm engendered by the novel technique, or some other mechanism is outside the scope of this study. However, the connection here is interesting because the patients (subjects) presented with pain in association with muscle tension or headache – a situation indicative of a psychosomatic connection. Further, the established degree of the reduction in anxiety and depression (the HAD scale) also implicates a psychosomatic connection, with the

potential for reducing anxiety and depression. It should be noted that 'optimists' found the treatment to be more pleasant than 'pessimists'. These observations agree with earlier reports demonstrating that flotation-REST is a technique that increases well-being, and decreases tension and anxiety (7,8,13,19). Further associations among personality variables and overall experiences are presented in Table 4, which indicates that the time to fall asleep correlated with MHPG, anxiety and depression. This observation is relevant because alterations in noradrenaline neurotransmission and metabolism, and sleep difficulties have been implicated in anxiety and depression. Additionally, it was found that the personality trait of dispositional optimism (as indexed by the LOT test) correlated negatively with depression and anxiety (as indexed by the HAD scale). This relationship between LOT and HAD does not provide new insights into flotation-REST as a method for pain relief but may indirectly confirm the validity of each test. However, there is no sure means of ascertaining the extent to which the participants' pain complaints were of a psychosomatic nature. Gustafson and Källmén (36) found that pain patients showed higher manifest anxiety than patients presenting with pain judged to be of a clearly somatic type. If this is the case, pain reduction may induce anxiety-reducing and general antidepressive effects.

Flotation-REST has been employed in the treatment of sleep problems (10). In the present study, there were no changes with regard to either the duration of sleep or the quality of sleep, but there was a significant reduction in the time taken to fall asleep. One condition for falling asleep is being able to relax. Thus, the present result supports the possibility that flotation-REST suppresses anxiety and the generation of negative emotional patterns, and facilitates the acquisition of more effective relaxation techniques. In this regard, it should be noted that the control patients had to remain on a waiting list for the flotation-REST treatment. Thus, it is possible that at least a part of the ameliorative effects may not be due to flotation-REST but that a more general effect might have been induced by the attention the patients received, by a higher level of activity/engagement (ie, leaving home nine times in three weeks), and possibly increased levels of self-efficacy (see LOT result), attention-placebo (ie, receiving the same amount of attention from the experimenters involved), etc. It is unfortunate that no follow-up procedure, particularly one reversing the control and experimental groups for flotation-REST, was incorporated in the experimental design; this might have indicated the longevity of effects, from which the clinical and economical utility might have been noted.

It is possible that the observed pre- to post-treatment reduction in the noradrenaline-metabolite MHPG reflects an altered stress-relaxation relationship in these individuals. However, it must be noted that circulating levels of noradrenaline are known to modulate pain thresholds (37). In the present study, endorphin levels were not affected directly, although, for unknown reasons, the control group indicated higher levels than the experimental group at both

pre- and post-treatment measurements. There were no measures of serotonin metabolites in the present study. There is a vast amount of evidence not only for the role of serotonin in the pharmacology of pain but also for the intricate serotonergic-noradrenergic interactions (38), while the relative roles of these neurotransmitter systems is evident in stress-induced analgesia (39). Further, serotonergic mechanisms have been shown to be involved in beta-endorphin-mediated analgesia (40). Thus, it is imperative that further investigations of flotation-REST efficacy in chronic pain alleviation include measures of the serotonin metabolite 5-hydroxyindole acetic acid.

Independent of whether flotation-REST influences levels of endorphins, other biologically active markers may be directly or indirectly affected by the treatment, possibly through a complex array of feedback mechanisms. Independent of which circulating biological markers may be implied in the experienced pain reduction, it is necessary to consider which changes represent cause and effect, respectively. Altered concentrations of endogenous compounds may trigger or be triggered by deeply underlying psychological functioning that may be influenced by situations in which an individual experiences an altered state of consciousness or deep relaxation.

The most common experiences that were deviations from a normal state were: 'feeling of floating', 'my body feels wonderful', 'dream-like alteration of time and space perspective', 'feeling of intense peace' and 'feeling of falling asleep'. These experiences may largely be described as a pure relaxation effect. Subjects who experienced 'inner images/visions and noises/voices' and experiences characterized by 'unity, limitless, religious' have emerged from more intense experiences than those that have been described as pure effects of relaxation.

CONCLUSIONS

The results of the present study tentatively suggest that flotation-REST may offer an effective method of alleviating low to moderately severe pain induced by muscle tension. Further investigations are aimed at extending the scope of the subjective changes and the neurochemical markers (eg, with the serotonin metabolite 5-hydroxyindole acetic acid, oxytocin and cortisol) followed by a comprehensive six-month follow-up investigation.

ACKNOWLEDGEMENTS: This article was supported by grants from Karlstad University, Sweden. The study has had ethical approval from the Ethical Board on Experimentation on Human Subjects (Forskningsetikommittén) at Karlstad University.

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