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MASSAGE THERAPY OF MODERATE AND LIGHT PRESSURE AND VIBRATOR EFFECTS ON EEG AND HEART RATE

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Three types of commonly used massage therapy techniques were assessed in a sample of 36 healthy adults, randomly assigned to: (1) moderate massage, (2) light massage, or (3) vibratory stimulation group (n = 12 per group). Changes in anxiety and stress were assessed, and EEG and EKG were recorded. Anxiety scores decreased for all groups, but the moderate pressure massage group reported the greatest decrease in stress. The moderate massage group also experienced a decrease in heart rate and EEG changes including an increase in delta and a decrease in alpha and beta activity, suggesting a relaxation response. Finally, this group showed increased positive affect, as indicated by a shift toward left frontal EEG activation. The light massage group showed increased arousal, as indicated by decreased delta and increased deta activity and increased heart rate. The vibratory stimulation group also showed increased arousal, as indicated by increased heart rate and increased theta, alpha, and beta activity.

Keywords EEG, EKG, massage, stimulation, touch

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Massage therapy, one of the oldest treatment modalities, has been re-emerging as one of the most popular forms of alternative therapy. Despite its long history, controlled studies have only recently been conducted to assess the biochemical, physiological, cognitive, and emotional effects of massage therapy (Field, 1998), and no studies have yet evaluated different pressure massage therapy and vibrator effects.

Recent studies indicate that massage therapy can: (1) decrease anxiety levels (Field, Morrow, Valdeon, Larson, Kuhn, & Shanberg, 1992; Field, Ironson, Pickens, Nawrocki, Goncalves, & Burman, 1996); (2) decrease depressed mood (Field, Seligman, Scafidi, & Shanberg, 1997; Jones & Field, 1999); (3) increase alertness as suggested by EEG patterns of alertness (Field et al., 1996); (4) enhance cognitive performance as suggested by increased performance on math computations (Field et al., 1996); and (5) alter biochemical (catecholamines, serotonin, and cortisol) levels in a positive direction (Hernandez-Reif, Dieter, Field, Swerdlow, & Diego, 1998; Kuhn, Shanberg, Field, Symanski, Zimmerman, Scafidi, & Roberts, 1991).

Only three studies have examined the effects of massage therapy on EEG activity (Field et al., 1996; Jodo, Yamada, Hatayama, Abe, & Maruyama, 1998, Jones & Field, 1999). In one study, participants receiving facial massage therapy exhibited decreased alpha and beta power, an EEG pattern that may reflect attention and alertness (Klimesch, Doppelmayer, Russegger, Pachinger, & Shwaiger, 1998; Shagass, 1972; Nunez, 2000). Similarly, adults receiving 15 min of massage therapy showed a pattern of increased delta power and decreased alpha and beta (Field et al., 1996), suggesting increased relaxation and alertness (Niedermeyer, 1982). Another study examining the effects of massage therapy on EEG showed that following 15 min of massage therapy, depressed adolescents showed less right frontal EEG asymmetry (Jones & Field, 1999). Right frontal EEG asymmetry has been related to negative mood and affect and may be a marker for depression (Davidson, 2000).

Few controlled studies have evaluated different pressure or different massage therapy techniques. One study that assessed blood flow in response to deep pressure stroking versus percussion movements revealed that only the percussion movements increased blood flow (Hovind & Nielsen, 1974). In another study assessing

alpha motor neuron excitability, deep pressure massage reduced H-reflex excitability, whereas light fingertip pressure did not (Sullivan, Williams, Seaborne, & Morelli, 1991). This finding supports data from other studies that have shown that deep pressure stroking produces significant physiological and psychological effects, whereas light pressure stroking does not. For example, one study assessing limb blood flow by a Doppler Ultrasound failed to show any effects of light pressure stroking (Shoemaker, Tiidus, & Mader, 1997). In contrast, a study assessing the effects of deep pressure massage found an increased range of motion and changes in electroneuromyograpy (ENMG) following treatment (McKechnie, Wilson, Watson, & Scott, 1983). In this pilot study, mean heart rate (BPM) and EMG activity decreased, while skin resistance (SRL) increased in response to connective tissue massage (deep pressure). Vibratory stimulation has been shown to enhance relaxation and decrease pain in adults (Lundeberg, 1984; Ottoson, Ekblom, & Hansson, 1981).

The present study assessed the physiological and psychological effects of three different massage therapy techniques, including light pressure and deep pressure massage provided by hands and vibratory stimulation provided by a mechanical massager (Thumper Mini Pro, Model #NAOOP, Worldwide Patents). The physiological effects of the three massage conditions were assessed by monitoring heart rate and EEG data from each participant and also assessed anxiety and stress on self-report scales.

As in previous studies, moderate pressure stimulation was expected to produce decreased heart rate, negative affect, and anxiety. EEG for this condition was expected to reflect increased delta and decreased alpha and beta power, suggesting a pattern of relaxation and alertness and a shift toward greater left frontal EEG asymmetry, suggesting greater positive affect. No specific effects were hypothesized for the low pressure or the vibratory stimulation groups.

METHOD

Participants

The sample included 36 faculty and staff members of a large urban medical school (58% females, 42% males, *M* age = 28). They were

middle- to upper-middle socioeconomic status (M = 2.58 on the Hollingshead), and were 58% Caucasian, 25% Hispanic, 9% African American, and 8% Asian. The participants were randomly assigned to a light pressure touch, moderate pressure touch, or vibratory stimulation condition.

Assessment Procedures

The procedure was conducted in the following order: (1) an EEG cap was positioned on the participants' head; (2) EKG electrodes were placed along the participants' arms; (3) participants completed the session baseline measures, including the *demographic questionnaire*, the *State Anxiety Inventory* (STAI; Spielberger, Gorsuch, & Luschene, 1970), the *visual analogue stress/relaxation scale*, and the *Touch Aversion Questionnaire*; (4) a 3-min baseline, followed by the 10-min massage was given, and a 3-min post session, during which EEG and EKG were continuously recorded; (5) followed by the *STAI* and the *visual analogue stress/relaxation scale*.

EEG Procedures

EEG was recorded for 3-min periods prior to 10 min during and 3 min after the massage, with the subjects' eyes closed. The EEG was recorded using a lycra stretchable cap (Electro-Cap, Inc.), positioned on the participant's head using the standard 10–20 system. Electrode gel was inserted into the midfrontal (F3 & F4), central (C3 & C4), anterior temporal (T3 & T4), and parietal (P3 & P4) sites and referenced to the vertex (Cz) during recording. Impedances were brought below 5K ohms. The EEG signals were amplified using Biopac EEG100B amplifiers. The output from the amplifiers was directed to a Dell Inspiron 7000 laptop computer fitted with the Biopac MP100 Acquisition System. The signal was sampled at a rate of 512 samples per second, streamed onto the computer screen, and then saved to a hard drive.

EEG was then computed off-line to derive a computer-averaged site reference, and then it was edited for artifact, using software designed by James Long, Inc. The artifact-free data were spectrally analyzed using a discrete Fourier transform with a Hanning window,

with 50% overlap to yield power values (in uV^2) for the following frequency bands: 1–4 Hz (delta); 5–7 Hz (theta); 8–12 Hz (alpha); 13–20 Hz (low beta) and 21–30 Hz (high beta). These values were then log transformed to normalize the data, and asymmetry scores were then computed. Asymmetry scores represent the difference of mean log power density scores in a right hemisphere site and its homologous left hemisphere site (lnRight-lnLeft). To be con-sistent with a previous study (Field et al., 1996) and to have an adequate variable to participants' ratio, only frontal EEG values were analyzed.

EKG Procedures

EKG was obtained for 3 min—pre, during, and post massage—by placing 3 EKG electrodes in a standard configuration along the participants' inner arms. The EKG signals were amplified using a Biopac EKG100B amplifier. The output from the amplifiers was directed to a Dell Inspiron 7000 laptop computer fitted with the Biopac MP100 Acquisition System. The signal was sampled at a rate of 512 samples per second and streamed onto the computer screen, and then saved to a hard drive. EKG data were then edited for artifact, and beats-per-minute (BPM) were computed off-line using AcqKnowledge software.

Touch Aversion Questionnaire

The Touch Aversion Questionnaire is a 24-item questionnaire that measures sensitivity to touch, with 1 representing "no," 2 "a little," and 3 "a lot." Characteristic items include "Do fuzzy shirts bother you?" and "Does it bother you to have your face touched?" A summary score is obtained by adding the weight of each item. Higher scores indicate greater touch aversion.

Pre-Post Self-Report Measures

The following measures were used to assess the immediate effects of the different types of massage. The STAI (Spielberger et al., 1970) is a 20-item scale that measures transitory anxiety levels in

terms of severity, with 1 representing "not so much" and 4 representing "very much." Characteristic items include "I feel tense" and "I feel relaxed." The STAI has adequate concurrent validity (Spielberger, 1972) and internal consistency (r = .83; Spielberger et al., 1970). In addition, the STAI scores an increase in response to situational stress and a decline under relaxing conditions. A summary score is obtained by adding the weight of each item. A *visual analogue scale* was used to assess the stressed-relaxed state with a score of O reflecting feeling "very tense" and a score of 10 being "very relaxed."

Massage Procedures

Following a 3-min baseline recording, participants received a moderate pressure massage, a light pressure massage, or a vibratory massage. Participants in all conditions received 10 min of stimulation to the back, shoulders, and arms by a trained massage therapist, while sitting fully clothed in a standard massage chair. The moderate *pressure massage* consisted of long, deep pressure stroking, and squeezing; the *light pressure massage* consisted of long, light pressure stroking; and the *vibratory massage* consisted of the Thumper (hand held massager) vibrating at 40Hz on the deep pressure setting.

The massage therapists were trained on the protocol and did not play another role in the study. All therapists were kept blind to the pressure hypothesis. Intermittent re-evaluation by the researchers ensured protocol compliance, especially with respect to the amount of pressure provided. Those therapists providing the light pressure massage did not perform deep pressure massage or vibratory massage and vice versa.

RESULTS

Demographics

Chi-square tests and independent sample t-tests were conducted on the demographic variables. These analyses revealed that the massage and relaxation therapy groups did not significantly differ on any of

the demographic variables (Table 1). The groups did not differ on their mean Touch Aversion Questionnaire scores (Table 1).

Pre-Post Self-Report Measures

Two separate group (Light/Moderate/Vibratory) by time (pre/post) repeated measures analyses of variance were conducted on STAI and visual analogue scale scores (Figure 1). A significant main effect for time, $F(1, 33) = 43.11$, $p < .001$, revealed that state anxiety scores decreased following all three conditions. A significant group by time interaction, $F(2, 33) = 8.75$, $p < .001$, was found for visual analogue scale scores. In order to evaluate this interaction, subsequent bonferroni corrected *t*-tests were conducted on visual analogue scale change scores, revealing that participants in the moderate massage group reported a greater decrease in self-reported stress than participants in the light massage $t(22) = 3.60$, $p < .01$ or the vibratory massage group $t(22)$, 2.58, $p < .05$.

TABLE 1. Means (and standard deviations) for demographics of light and moderate pressure massage and vibratory stimulation groups

	Light (N = 12)	*Moderate (N = 12)*	*Vibratory (N = 12)*	
Age	29.92 (10.29)	29.58 (8.32)	27.42 (9.57)	$F(2, 33) = 0.25$, N.S.
SES	2.25 (0.62)	2.75 (0.75)	2.75 (0.45)	$F(2, 33) = 2.59$, N.S.
Sex				
Male	58%	17%	50%	$\chi^2(2) = 4.80$, p = N.S.
Female	42%	83%	50%	
Ethnicity				$\chi^2(6) = 6.00$, p = N.S.
Caucasian	33%	67%	75%	
African American	8%	8%	8%	
Hispanic	42%	17%	17%	
Other	17%	8%	0%	
Touch aversion	35.08 (5.59)	34.25 (3.82)	35.75 (5.56)	$F(2, 33) = 0.27$, N.S.

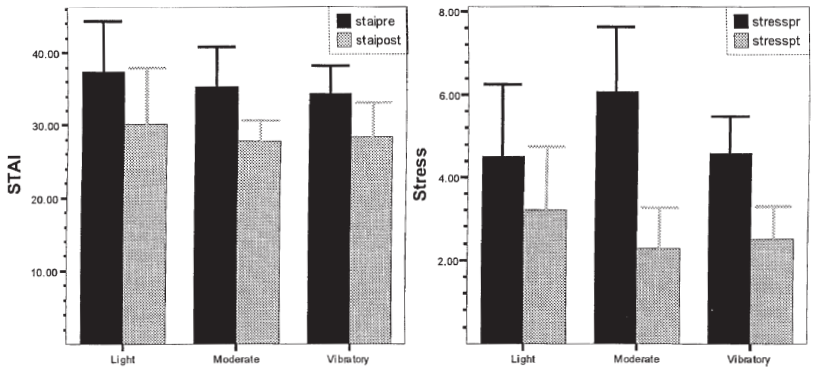

FIGURE 1. Mean pre-post self-reported anxiety (STAI) and stress scores (error bars indicate ± 2 SE) for light and moderate pressure and vibratory stimulation groups.

EEG Measures

Five separate group (Light/Moderate/Vibratory) by trial (pre/during/post) repeated measures analyses of variance were conducted on frontal EEG delta, theta, alpha, beta, and alpha asymmetry values. The analysis for frontal delta EEG values revealed a significant group by trial interaction, $F(4, 56) = 2.80$, $p < .05$. In order to understand this interaction, separate trend analyses were conducted for each group. These analyses revealed a significant linear trend for the light massage group, $F(1, 11) = 4.93$, $p < .05$, suggesting a decrease in frontal delta power during and following light massage. A significant quadratic trend was revealed for the moderate massage group, $F(1, 9) = 8.97$, $p < .05$, involving an increase in frontal delta power during the deep massage procedure, and then a return to baseline. The analyses for the remaining EEG measures revealed significant main effects for frontal alpha $F(2, 56) = 3.65$, $p < .05$, beta $F(2, 56) = 3.57$, $p < .05$, and alpha EEG asymmetry $F(2, 56) = 4.95$, $p < .05$. In order to understand better these effects, trend analyses were conducted revealing the following: (1) a significant quadratic trend for frontal alpha power $F(1, 28) = 3.99$, $p < .05$, suggesting that alpha power significantly decreased and then returned to baseline across all massage procedures; (2) a significant linear trend for frontal beta power $F(1, 28) = 8.18$, $p < .01$, suggesting that beta power significantly decreased and then returned to baseline across all massage

TABLE 2. Means (and standard deviations) for frontal EEG delta, theta, alpha, beta, and frontal EEG asymmetry (right minues left) log power values for light and moderate pressure massage and vibratory stimulation groups

	Light			*Moderate*			*Vibratory*		
	Pre	*Dur*	*Post*	*Pre*	*Dur*	*Post*	*Pre*	*Dur*	*Post*
Delta (1–4 Hz)	3.45	3.10	3.10 ↘	3.36	3.68	3.49 ↘↗	3.07	3.05	3.14
Group × *Trial*	1.33	1.12	1.07	1.39	1.21	1.34	1.07	0.74	1.17
Theta (5–7 Hz)	2.02	1.69	1.93	1.99	1.96	2.16	1.90	1.81	2.00
	0.81	0.61	0.61	0.98	0.85	0.81	0.55	0.67	0.81
Alpha (8–12 Hz)	3.01	2.64	2.79	3.15	2.82	2.93	3.04	2.82	3.08
Trial ↘↗	0.96	0.94	0.92	1.22	1.18	1.29	1.05	0.90	0.80
Beta (13–20 Hz)	2.32	2.13	2.41	2.41	2.20	2.28	2.36	2.27	2.39
Trial ↘↗	0.67	0.73	0.70	1.03	1.09	1.10	1.16	1.10	1.21
Alpha asymmetry	–0.09	–0.04	–0.01	–0.32	0.00	0.01	–0.25	–0.25	–0.20
Trial ↗	0.38	0.27	0.37	0.45	0.19	0.16	0.43	0.36	0.34

↘ indicates significant linear trend; ↘↗ indicates significant quadratic trend. *Trial* indicates significant main effect for trial (pre/during/post); *Group* × *Trial* indicates significant group by trial interaction.

procedures; and (3) a significant linear trend for frontal alpha asymmetry $F(1, 28) = 8.55$, $p < .01$, suggesting that participants became more left frontal. Moderate pressure massage procedure resulted in the greatest proportion of adults exhibiting a shift toward left frontal EEG asymmetry (90% versus 75% for the light pressure massage and 56% for the vibratory stimulation), and the analyses for frontal EEG asymmetry yielded a marginal group by trial interaction, $F(4, 56) = 2.10$, $p = .093$; separate trend analyses on frontal EEG asymmetry values were conducted for each group. These analyses revealed that only the moderate pressure massage exhibited a significant linear trend towards left frontal EEG asymmetry, $F(1, 9) = 5.59$, $p < .05$ (Figure 3).

Heart Rate

A group (Light/Moderate/Vibratory) by trial (pre/during/post) repeated measures analysis of variance was conducted on heart rate values. This analysis revealed a significant group by trial interac-

tion, $F(4, 66) = 2.52$, $p < .05$. In order to understand this interaction, post-hoc bonferroni corrected t-tests were conducted, revealing that moderate massage group showed a significant decrease in heart rate during the massage, $t(11) = 5.89$, $p < .05$, which continued into the post session, $t(11) = 3.25$, $p < .05$, while the light massage group showed a significant increase in heart rate following the massage $t(11) = 3.40$, $p <. 05$. The vibratory stimulation group exhibited a marginal increase in heart rate following the massage $t(11) = 2.55$, $p < .08$.

DISCUSSION

The effects of three types of massage were evaluated on a group of healthy participants revealing significant effects on self-report measures of anxiety and stress and on EEG and heart rate. Regardless of the massage procedure received, participants reported feeling less anxious and stressed. However, the moderate massage procedure resulted in the greatest decrease in self-reported stress. The decrease in self-report anxiety and stress is consistent with findings from

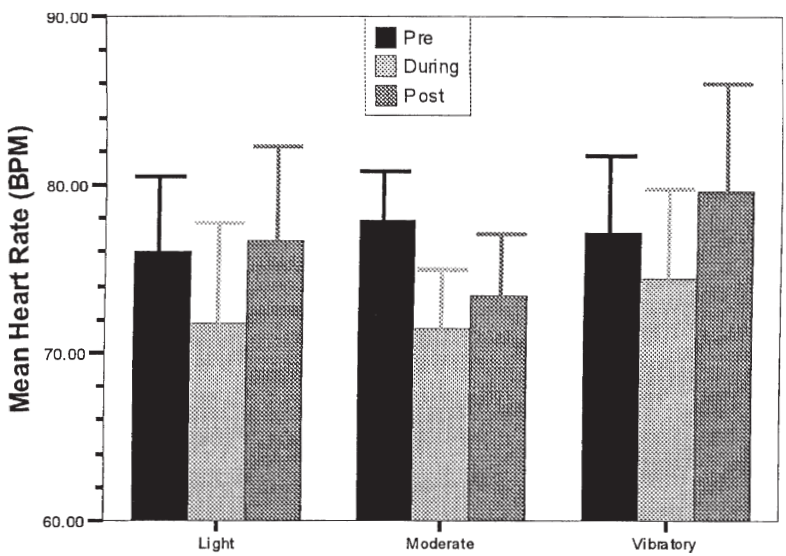

FIGURE 2. Mean heart rate in beats per minute (error bars indicate ± 2 SE) for light and moderate pressure massage and vibratory stimulation groups.

several studies, indicating that moderate massage therapy is effective in reducing stress and anxiety, as indicated by self-report assessments and decreases in cortisol (Field, 2002).

Consistent with the self-report data and previous findings (Field et al., 1996; McKechnie et al., 1983), the moderate massage therapy group exhibited both an increase in frontal EEG delta during the massage and a decrease in heart rate during and after the massage. Slow wave EEG activity (delta power) is associated with lower arousal and relaxation (Niedermeyer, 1982), as are decreases in heart rate (Mok & Wong, 2003). Contrary to the moderate pressure massage, the light pressure massage resulted in a decrease in frontal delta power during and after the massage and an increase in heart rate following the massage, suggesting increased arousal and decreased relaxation. Unlike the massage groups, the vibratory stimulation group did not exhibit any changes in slow wave EEG activity (delta or theta) and only a marginal increase in heart rate following the stimulation. Taken together these findings indicate that moderate pressure massage resulted in enhanced relaxation, while the light pressure massage resulted in physiological arousal and decreased relaxation. Further, the vibratory stimulation appeared to have negligible effects on physiological levels of arousal and/or relaxation.

The significant decrease in alpha and beta power across groups during the massage/stimulation period is consistent with previous findings (Jodo et al., 1988; Field et al., 1996). Faster wave EEG activity (alpha and beta) is inversely related to alertness and attention (Klimesch et al., 1998; Shagass, 1972; Nunez, 2000), as well as sensory processing (Bastiaansen, Bocker, Brunia, de Munck, & Spekreijse, 2001). As such, the decrease in alpha and beta may have reflected attention to, and sensory processing of, the stimulation being applied to the participants. Contrary to findings from a previous study (Field et al., 1996), the decrease in alpha and beta for the moderate massage group was only evident during the massage period. It is possible that this discrepancy in findings may have resulted from the lack of power, given our small sample size (n = 12 vs. n = 26 in the Field et al., 1996 study) and/or from the shorter duration of the massage being administered (10 min vs. 15 min in the Field et al., 1996 study). Future research should address the effects of varying lengths of massage therapy on EEG.

All groups exhibited a mean shift towards greater left frontal asymmetry during and after the massage/stimulation periods. However, compared to the light pressure massage and the vibratory stimulation, the moderate pressure massage resulted in a shift towards left frontal EEG asymmetry for almost all participants. Asymmetries in frontal brain electrical activity are thought to reflect the processing (Davidson, 1998, 2000) and regulation of emotion (Fox, 1994). For example, greater right frontal EEG asymmetry is manifested during the expression and regulation of negative/withdrawal emotions, while greater left frontal EEG alpha asymmetry is manifested during the expression of positive/approach emotions (Davidson, 1998; Davidson, 2000). As such, the shift toward left frontal EEG

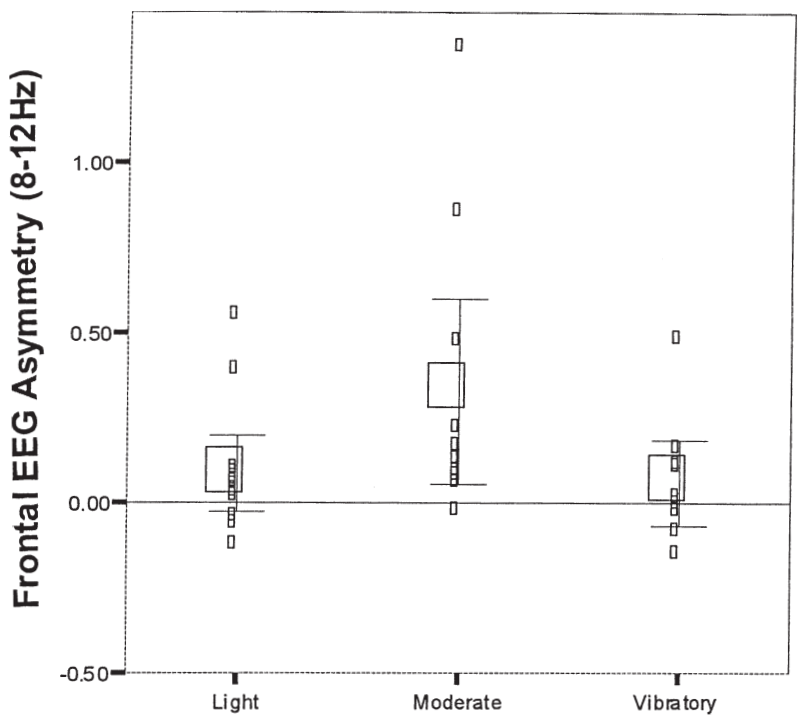

FIGURE 3. Change in frontal EEG asymmetry scores (log right – log left 8–12 Hz power) for light and moderate massage and vibratory stimulation groups. Positive values indicate a shift toward left frontal EEG asymmetry, and negative values indicate a shift toward right frontal EEG asymmetry. Horizontal lines indicate means, error bars indicate ± 2 SE, and triangles indicate individual scores.

asymmetry suggests that the moderate and light pressure massage, as well as the vibratory stimulation were perceived as being pleasant. This is consistent with the lower anxiety and stress levels reported across all groups. However, just as with the reduction in self-reported stress levels and decreased heart rate, the greatest shift towards left frontal EEG asymmetry for the moderate pressure massage suggests that this modality was more pleasant and relaxing than either the light pressure massage or the vibratory stimulation.

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