

## Original Papers

# Psychoneuroimmunologic Effects of Ayurvedic Oil-Dripping Treatment

Kazuo Uebaba, M.D., Ph.D.,<sup>1,2</sup> Feng-Hao Xu, M.D.,<sup>1,2</sup> Hiroko Ogawa, M.S.,<sup>1,2</sup> Takashi Tatsuse, B.C.,<sup>3</sup>  
Bing-Hong Wang, Ph.D.,<sup>4</sup> Tatsuya Hisajima, Ph.D.,<sup>5</sup> and Sonia Venkatraman<sup>6</sup>

### Abstract

**Objective:** This study assessed the psychoneuroimmunologic changes achieved by *Shirodhara*, an Ayurvedic treatment, characterized by dripping oil on the forehead, in a randomized, controlled protocol involving a novel approach using a robotic system.

**Methods:** In the first experiment for the determination of the most appropriate conditions of *Shirodhara*, 16 healthy females ( $33 \pm 9$  years old) underwent a 30-minute treatment. In the second study, another 16 healthy females ( $39 \pm 9$  years old) were assigned to either the *Shirodhara* treatment or control supine position for 30 minutes, with monitoring of physiologic, biochemical, immunologic, and psychometric parameters including anxiety and altered states of consciousness (ASC).

**Results:** The subjects receiving *Shirodhara* treatment showed lowered levels of state anxiety and higher levels of ASC than those in the control position. Plasma noradrenaline and urinary serotonin excretion decreased significantly more after *Shirodhara* treatment than in the control. Plasma levels of thyrotropin-releasing hormone, dopamine, and natural killer (NK) cell activity were different between control and *Shirodhara* treatment. The correlation between anxiolysis and the depth of ASC was significant in the *Shirodhara* treatment group ( $r = 0.52$ ,  $p < 0.05$ ,  $N = 16$ ), while in the control no correlation was obtained ( $r = 0.13$ ,  $p = 0.64$ ,  $N = 16$ ). The increase in foot skin temperature after *Shirodhara* showed a significant correlation with anxiolysis and the depth of Trance of ASC ( $r = 0.58$ ,  $p < 0.01$ ,  $r = 0.43$ ,  $p < 0.01$ , respectively). NK cell activity after *Shirodhara* treatment showed a significant correlation with anxiolysis and the depth of Trance of ASC ( $r = 0.33$ ,  $p < 0.05$ ,  $r = 0.56$ ,  $p < 0.01$ , respectively).

**Conclusions:** These results indicate that *Shirodhara* has anxiolytic and ASC-inducing effects, and it promotes a decrease of noradrenaline and exhibits a sympatholytic effect, resulting in the activation of peripheral foot skin circulation and immunopotentialiation.

### Introduction

**S***hirodhara*, one of the healing techniques of Ayurveda, is characterized by dripping oil on the forehead. Originating in ancient India, Ayurveda is a science of life that uses various oil treatments for the proper balance of bioenergies in the body including oil massage and oil-dripping treatment such as *Shirodhara*. In Sanskrit, *shiro* means “head,” and *dhara*

means “dripping.” This method was originated from Kerliya *Panchakarma*, and is one of the components of the systematic purification techniques of *Panchakarma*.<sup>1</sup> *Panchakarma* is the most famous purification system in Ayurveda. A.K. Sharma suggested that *Shirodhara* may alleviate headache, mental stress, insomnia, depression, motor neuron diseases, and several kinds of mental disorders, including schizophrenia.<sup>1</sup> Furthermore, he suggested that it may have an anti-analgesic

<sup>1</sup>Department of Presymptomatic Health Promotion, Institute of Natural Medicine, University of Toyama, Toyama, Japan.

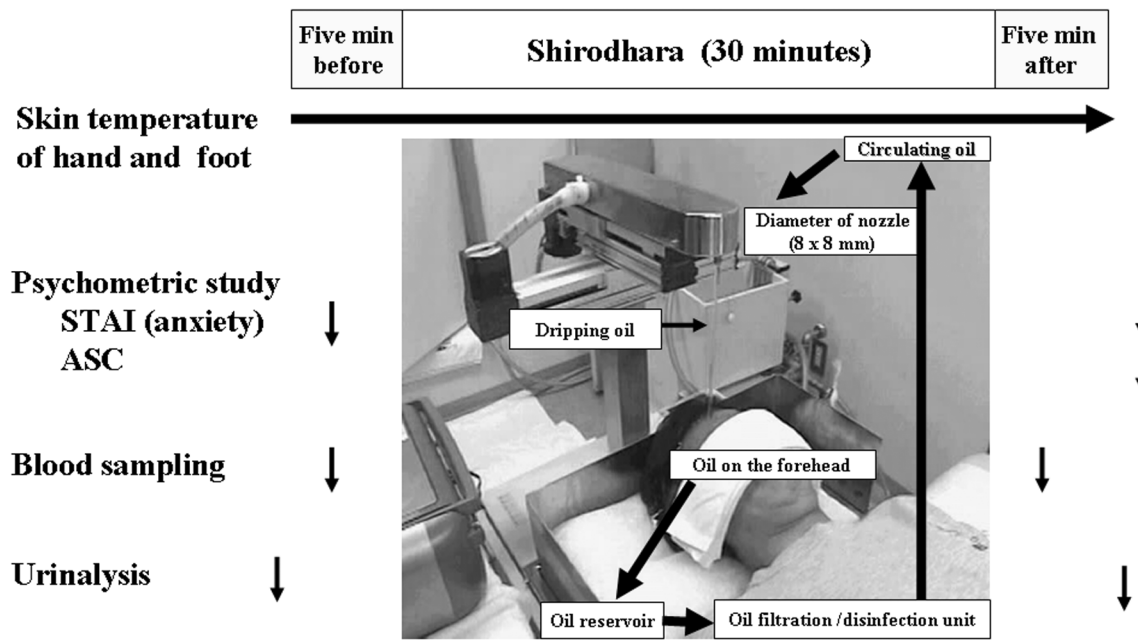
<sup>2</sup>International Research Center for Traditional Medicine of Toyama Prefecture, Toyama, Japan.

<sup>3</sup>Department of Welfare Promotion and Epidemiology, University of Toyama, Toyama, Japan.

<sup>4</sup>Department of Public Health, Hiroshima University, Hiroshima, Japan.

<sup>5</sup>Faculty of Health Care, Department of Alternative Medicine, Teikyo Heisei University, Tokyo, Japan.

<sup>6</sup>Department of Clinical Psychology, University of Oregon, Oregon City, OR.



**FIG. 1.** Set-up and timetable of the experiment. STAI, State-Trait Anxiety Inventory; ASC, altered states of consciousness. Oil flow rate: 2.3 L/min; height of the nozzle tip: 20 cm over the forehead; moving speed of the nozzle: 1.5 cm/second (slowest); oil temperature: 39°C (at nozzle); room temperature: 27 ± 0.5°C. Downward arrows indicate times of checking.

effect.<sup>1</sup> H.M. Sharma et al. reported the anxiolytic effect of all treatments comprising *Panchakarma*.<sup>2</sup> However, there has been little research on the psychophysiological or psychoneuroimmunologic changes brought about by *Shirodhara*.<sup>3,4</sup> The psychologic effects, especially those regarding altered states of consciousness (ASC), of *Shirodhara* have not yet been studied. We have already reported that *Shirodhara* exhibited an anxiolytic effect and that it induced ASC, activation of the peripheral circulation, as well as a sympatholytic effect, in a noncontrolled study.<sup>3,4</sup> We have also reported that during *Shirodhara*, the heart rate and CO<sub>2</sub> excretion decreased, and an alternative marker of sympathetic tone, the ratio of LF (low-frequency power)/HF (high-frequency power calculated from electrogram-R-R wave variability), was suppressed.<sup>3</sup>

We have adopted a modern approach employing robotics to regulate oil dripping on the forehead during *Shirodhara*.

This robotic system facilitates reproducibility regarding the oil temperature, oil flow rate, speed of movement of the dripping nozzle, and patterns of oil dripping on the forehead for 30 minutes in *Shirodhara*. There are several kinds of *Dhara* techniques depending on the medium for dripping. *Taila Dhara* uses medicated sesame oil mixed with cow’s milk, water, and herbs.<sup>1,5,6</sup> We studied the psychoneuroimmunologic changes during *Taila Dhara* with plain sesame oil in order to simplify the study.

To determine the most comfortable and safest condition of *Shirodhara*, we compared comfort levels during *Shirodhara* conducted using various conditions of oil temperature, oil flow rate, and duration. The psychoneuroimmunologic changes brought about by *Shirodhara* and the control supine position were measured following a randomly assigned study design using the most appropriate and safest conditions.

TABLE 1. THE 10 DOMAINS OF THE ALTERED STATES OF CONSCIOUSNESS IN PSYCHOMETRICS

Loss of space perception (Space): Feeling like floating
Loss of bodily sense (Body sense): Feeling like only mind existing without body
Trance (Trance): Enraptured
Passiveness (Passive): Feeling like being under someone’s control
Loss of knowing difference between subjectivity and objectivity (Sub.–Obj.) (no separation between oneself and others)
Loss of time perception (Time): No concept of time passing
Loss of speech sense (Speech): No desire to speak
Concentration (Conc.): Do not notice any change in surroundings
Momentariness (Moment.): Feels like only a short time has passed
Cosmic consciousness (C.C.): Experience such as to have seen the truth

Derived from Saito’s papers.<sup>8,9</sup>

TABLE 2. CHARACTERISTICS OF "TRANCE EXPERIENCE" OF THE ALTERED STATES OF CONSCIOUSNESS (ASC)

I was so happy and delightful in a trance.  
 I felt very happy after the states.  
 I felt as though hovering between dream and awakening.  
 Other people's voices and noises reached my ears as pleasant sounds like music.  
 I was in no mood for doing anything under the states.  
 I have lost myself in a trance-like state.

In each questionnaire, the following score was selected, and totals of six questions were recognized as the ASC score:

Yes: 5, So-so: 3, Not at all: 1 (4 and 2 points were between 3 and 5 or 3 and 1, respectively)

Derived from Saito's papers.<sup>8,9</sup>

## Methods

### Subjects

Sixteen (16) females (21–56 years old;  $33 \pm 9$  years old) who were physically and psychologically healthy participated in the first experiment for determining the most appropriate conditions of operating the robotic system, after giving written informed consent.

Another 16 healthy females (21–60 years old;  $39 \pm 9$  years old) participated in the second experiment investigating the psychoimmunologic changes brought about by *Shirodhara*, after giving informed consent. Because some subjects were menstruating, two experiments of *Shirodhara* and control supine were conducted 1 month later in order to correct for the hormonal changes owing to their menstrual rhythm.

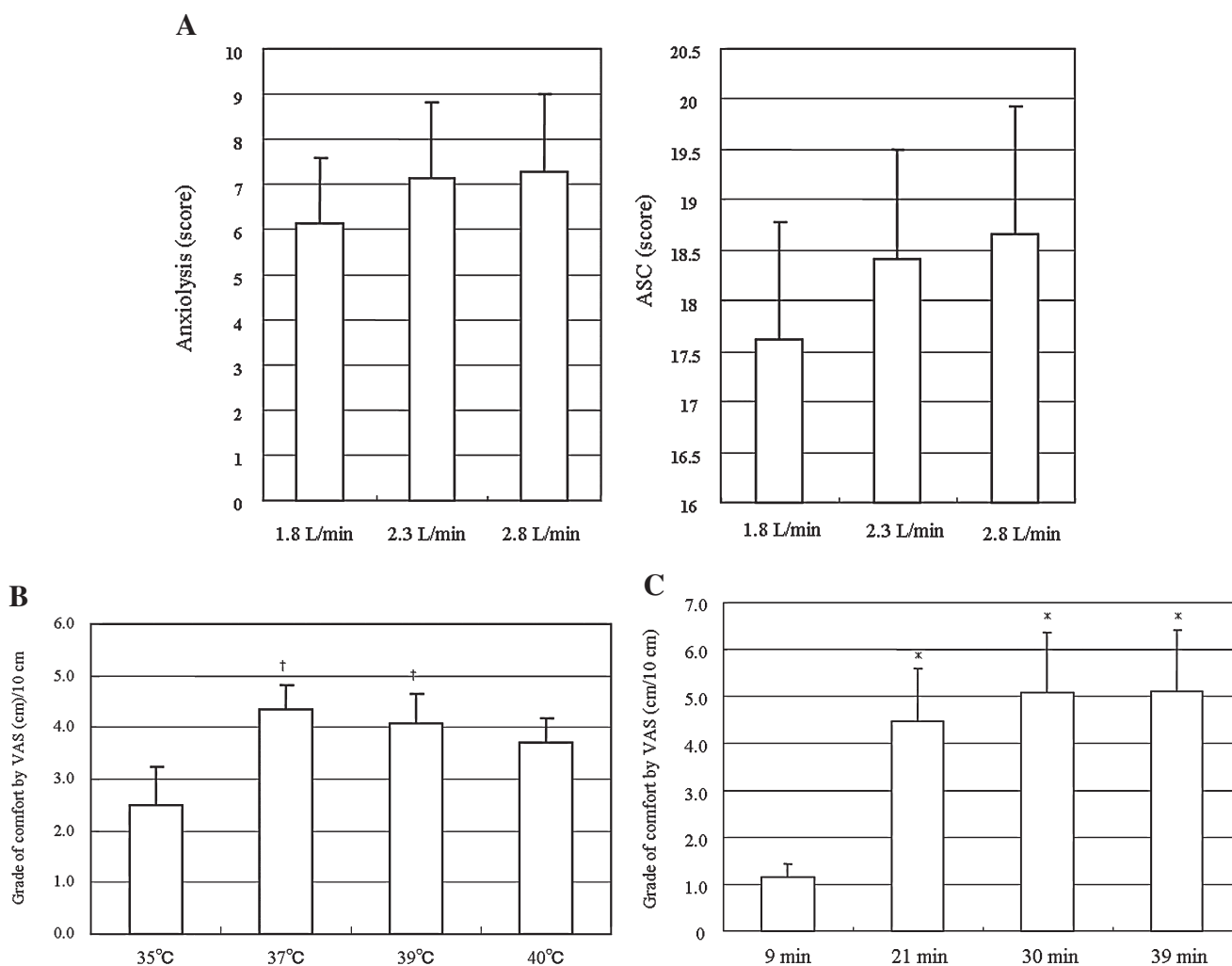


FIG. 2. (A) Oil flow rate and altered state of consciousness (ASC), and anxiolysis and ASC. (B) Oil temperature and comfort estimated by visual analogue scale (VAS). (C) Length of *Shirodhara* and comfort estimated by VAS scale. \* $p < 0.05$  by Dunnett's  $t$ -test versus 9 minutes <sup>†</sup> $p < 0.1$  by Dunnett's  $t$ -test versus 35°.

TABLE 3. PROCESS OF SELECTING OF THE MOST APPROPRIATE AND SAFEST CONDITIONS OF SHIRODHARA

Conditions	Anxiolytic effect rank	ASC-inducing effect rank	VAS for comfort rank	Total rank	Safety (complaints and troubles)
Duration	9 min	4	4	12	Not enough
	21 min	3	3	9	
	30 min	1	2	4	
	39 min	2	1	4	
Temp.	35°C	2	4	10	Headache, neck pain Chill Slight chill Too hot
	37°C	3	2	6	
	39°C	4	1	7	
	41°C	1	3	7	
Oil flow rate	1.8 L/min	3	3	6	Too much pressure
	2.3 L/min	2	2	4	
	2.8 L/min	1	1	2	

Rank is determined in three or four kinds of experiments, depending on the comfort of the treatments. Total rank is the summed ranks of each conditions. The lowest total rank indicates the best condition.  
 ASC, altered states of consciousness; VAS, visual analogue scale.

Various conditions of operating the robotic oil drip system

In order to compare the comfort levels during various conditions of *Shirodhara*, the robotic oil drip system (Fig. 1) was used to regulate the conditions. Four (4) oil temperatures (35°C, 37°C, 39°C, and 41°C at the nozzle), three oil flow rates (1.8, 2.3, and 2.8 L/min), and four different durations (9, 19, 29, and 39 minutes long) were candidate

parameters to achieve the most effective and safest condition of *Shirodhara*. Other fixed conditions for operating the robotics were as follows: The moving speed of the dripping nozzle was 1.5 cm/sec, and the nozzle height (distance from the forehead to the nozzle) was set at 20 cm. The patterns of dripping comprised temple, horizontal, and vertical movements involving two repetitions each of 5-minute movements.

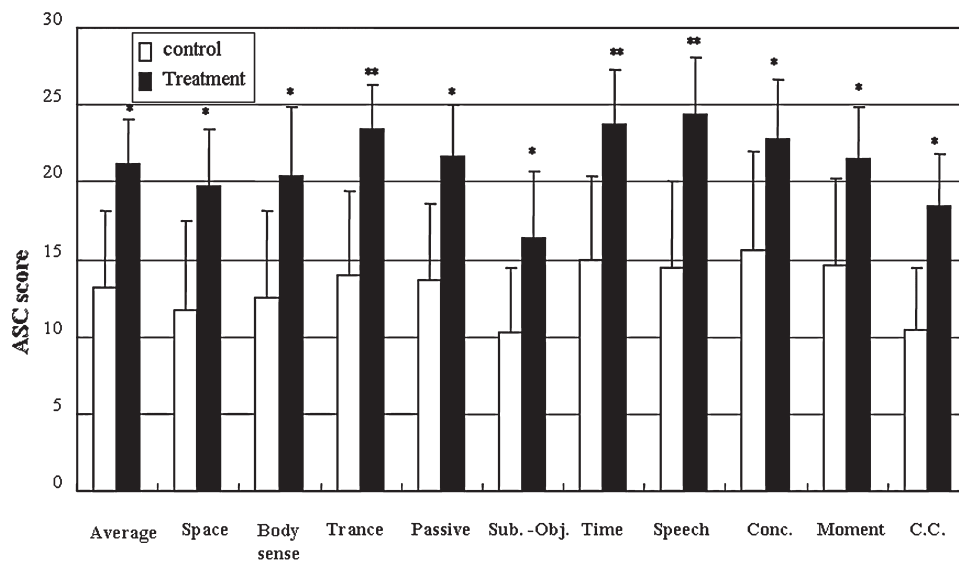


FIG. 3. Comparison of altered state of consciousness (ASC) by *Shirodhara* and control supine condition \* $p < 0.05$ , \*\* $p < 0.01$ ,  $N = 16$ , Wilcoxon signed rank test. Although the values are nonparametric, results are presented as the mean  $\pm$  standard error. ASC scores in the treatment are higher than that of control supine position in all the domains. Space, loss of space perception; Body sense, loss of bodily sense; Trance, subject is enraptured, Passive, Passiveness, Sub.-Obj., loss of subjectivity and objectivity; Time, loss of time perception; Speech, loss of speech sense; Conc., concentration, Moment, "Momentariness,"; C.C., cosmic consciousness.

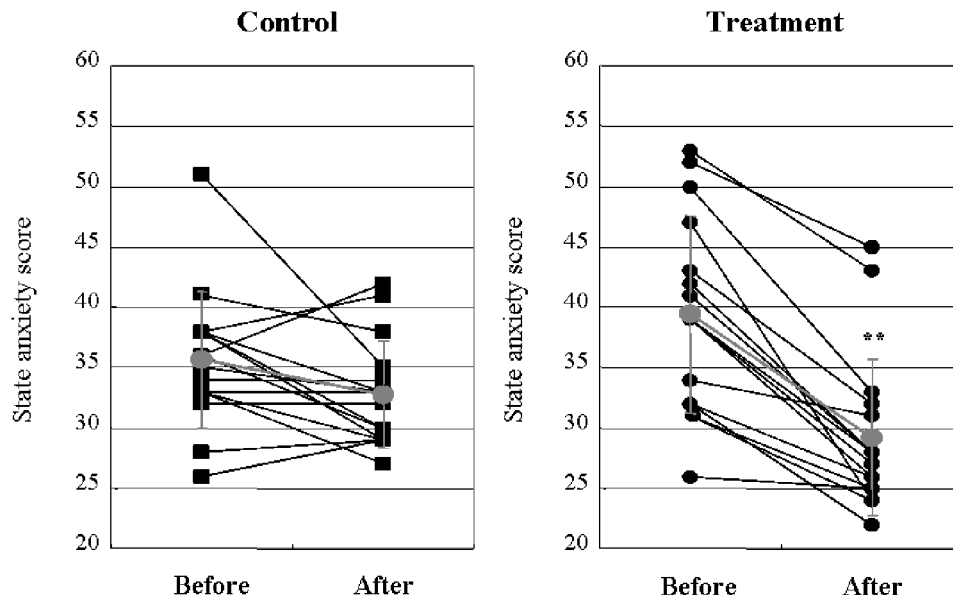


FIG. 4. Anxiolytic effect of *Shirodhara* (\*\* $p < 0.01$ ,  $N = 16$ , Wilcoxon signed rank test) in the treatment and control groups. Although the values are nonparametric, results are presented as the mean  $\pm$  standard error.  $p < 0.05$  by two-way analysis of variance in the change in the state anxiety of the two groups, when calculated as parametric values. *Shirodhara* treatment induced significant anxiolysis, without any change in the control supine position. Before, before *Shirodhara*; After, after *Shirodhara*.

#### Oil Used for *Shirodhara*

Although medicated oils are used for *Shirodhara* in general, plain sesame oil (Kadoya Oil Co.) was used as the medium during *Shirodhara* in this study in order to simplify it.

#### Randomized, controlled study

The sequence of the experiment with plain sesame oil and the control supine position was assigned in a random sequence. The study started after approval of the Ethical Committee of International Research Center for Traditional Medicine of Toyama Prefecture.

#### Examinations for the assessment of psychoneuroimmunologic changes

**Evaluation of comfort.** An original visual analogue scale (VAS) for comfort 100 mm long was used. Subjects checked the initial zero point of the VAS scale when they felt neither comfort nor discomfort, and the 100-mm point when they felt the most comfortable.

**Psychologic examinations.** Anxiety was assessed using the State-Trait Anxiety Inventory,<sup>7</sup> which is generally considered the "gold standard" for the evaluation of anxiety. Anxiolysis was calculated as the percent change between pre- and post-treatment assessments. The psychometric instrument for ASC<sup>8,9</sup> was used. ASC has been commonly misunderstood as peculiar experiences induced by psychotropic drugs.<sup>10,11</sup> Traditional healing techniques such as meditation often induce ASC.<sup>8,9</sup> Saito classified ASC into 10 kinds of experiences (10 domains; Table 1), and he created the ASC questionnaire in Japanese after ascertaining its reliability and specificity.<sup>8</sup> We used the ASC questionnaire de-

veloped by Saito,<sup>8</sup> and asked the subjects to answer it immediately after *Shirodhara* treatment. The questionnaires for trance experiences and method for calculation are shown in Table 2.

**Physical examinations.** Skin temperature of the dorsal side of the right hand and foot was monitored with thermocou-

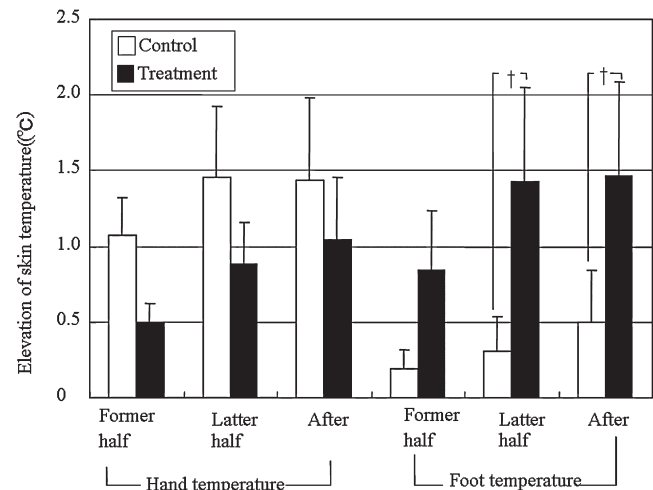
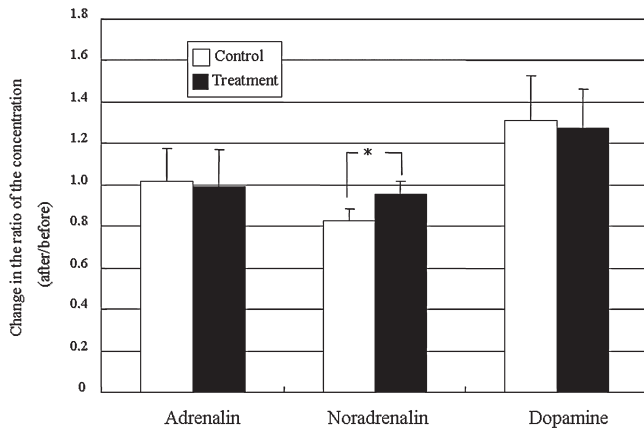


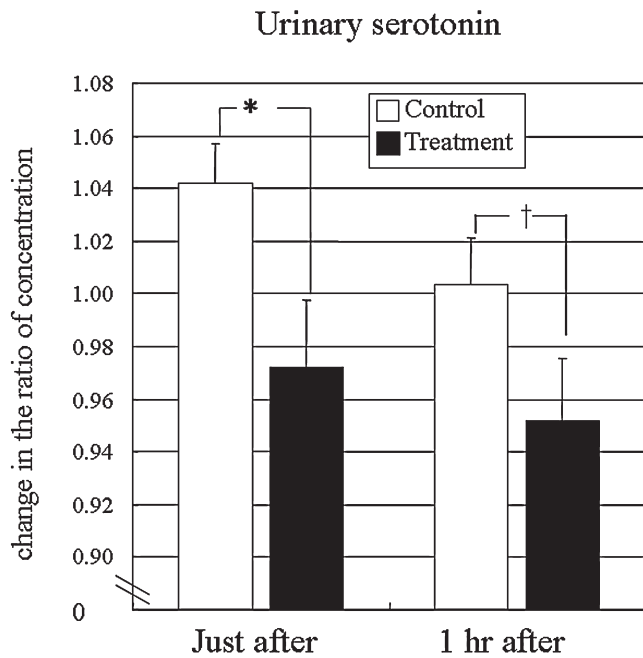
FIG. 5. Elevation in skin temperature of the hand and foot ( $p < 0.1$ ,  $N = 16$  mean  $\pm$  standard error, paired  $t$ -test between control and treatment group). Hand temperature was measured at the dorsum of the right hand, and foot temperature was measured at the dorsum of the right foot. Foot temperature in the treatment is higher than that of the control supine position from the latter half of *Shirodhara* treatment.



**FIG. 6.** Changes in plasma catecholamine (\* $p < 0.05$ , paired  $t$ -test,  $N = 16$ , mean  $\pm$  standard error). Changes in plasma noradrenalin in the treatment subjects is higher than that of the control subjects in the supine position.

ple sensors. The skin temperature was measured every 10 seconds and recorded. The changes in temperature were calculated as the average results in three stages of the experiment, for the hand and foot separately: (1) former half: during the initial half of *Shirodhara* treatment, (2) latter half: during the latter half of *Shirodhara*, and (3) after: after *Shirodhara*.

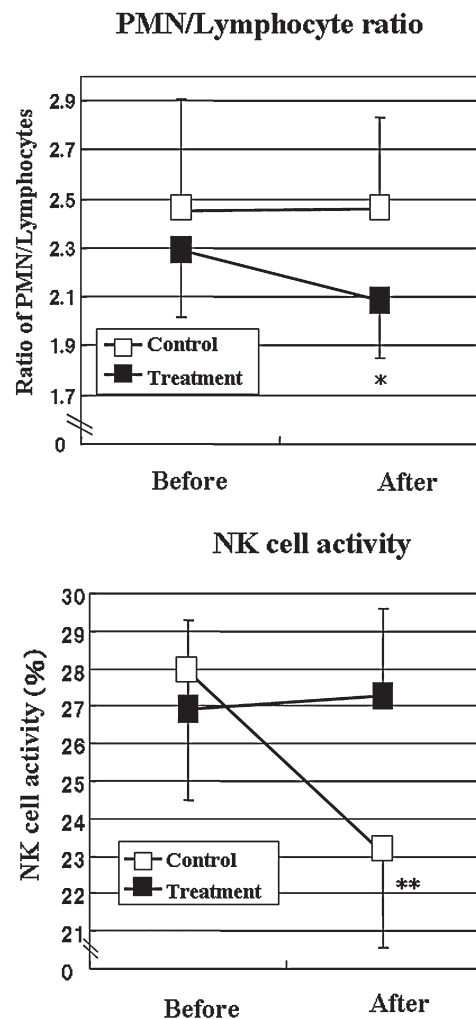
Neuroimmunologic examinations. Serum thyrotropin-releasing hormone (TRH) by radioimmunoassay (RIA), natural



**FIG. 7.** Changes in the urinary excretion of serotonin (\* $p < 0.05$ , † $p < 0.1$  by paired  $t$ -test,  $N = 16$ , mean  $\pm$  standard error). Serotonin concentration was corrected by the urinary creatinine concentration. Urinary serotonin excretion in the treatment group is significantly lower than that of the control subjects in the supine position.

killer (NK) cell activity (chromium uptake method, %), plasma catecholamine (adrenaline, noradrenaline, and dopamine by high-performance liquid chromatography: HPLC), and urinary serotonin (HPLC) corrected by the urinary creatinine concentration (measured by a calorimetric study) were examined by Mitsubishi Chemical Co. Ltd. The ratio of polymorphonuclear neutrophils (PMN) to lymphocytes in peripheral blood was calculated according to the white blood cell classification, as an indicator of autonomic nervous balance.<sup>12</sup>

**Statistical analysis.** For usual parametric values, one- and two-way ANOVA, paired  $t$ -tests, and Pearson's correlation coefficients were calculated. Wilcoxon signed-ranks test and Spearman's correlation coefficient tests were performed for



**FIG. 8.** Changes in the polymorphonuclear neutrophils (PMN)/lymphocyte ratio and natural killer (NK) cell activity after *Shirodhara* (\* $p < 0.05$ , \*\* $p < 0.01$ ,  $N = 16$ , mean  $\pm$  standard deviation, paired  $t$ -test). PMN/lymphocyte ratio decreased significantly in the treatment, without any change in the control spine position. NK cell activity decreased significantly in the control group, without any change in the *Shirodhara* treatment group. Before, before *Shirodhara*; After, after *Shirodhara*.

TABLE 4. COMPARISON OF REGRESSION COEFFICIENTS BETWEEN ALTERED STATES OF CONSCIOUSNESS (ASC) OR ANXIOLYSIS AND NK (NATURAL KILLER) CELL ACTIVITY OR SKIN TEMPERATURE ELEVATION

Correlationship	Groups						ANCOVA p-value
	Control supine position			Treatment			
	r	p-value	N	r	p-value	N	
Anxiolysis: Score of ASC (Trance)	0.13	0.64	16	0.52	<0.05	16	<0.05
Elevation of skin temp.: anxiolysis (%)	0.24	0.40	16	0.58	<0.01	16	>0.05
Elevation of skin temp.: ASC (Trance)	0.04	0.45	16	0.43	<0.05	16	<0.05
NK cell activity (%): Anxiolysis (%)	0.02	0.89	16	0.33	<0.05	16	<0.05
NK cell activity (%): Score of ASC (Trance)	0.20	0.46	16	0.56	<0.01	16	<0.05

*r*, regression coefficient; *N*, cases.

Significant correlations between ASC or anxiolysis and elevation of skin temperature or NK cell activity were obtained only in the treatment groups. Anxiolysis was determined by the change in state anxiety from before to after *Shirodhara*. Correlation coefficients were calculated by Spearman's method. Regression coefficients between ASC score (Trance) or anxiolysis and elevation of skin temperature or NK cell activity were significantly different between control and treatment groups on the assumption that ASC scores are parametric values ( $p < 0.05$ , ANCOVA).

ANCOVA, analysis of covariance; NK, natural killer.

nonparametric values. In some cases, when individual differences were large, the changes in the ratios in each study were compared by parametric tests. For the comparison of regression coefficients, analysis of covariance (ANCOVA) was performed. ANCOVA of the regression coefficients between nonparametric and parametric values was conducted on the assumption that both are parametric values. Significance levels were set as  $p < 0.05$  by Dunnett's *t*-test.

## Results

### *The most appropriate and safest conditions of operating the robotics of oil dripping.*

Figures 2A, 2B, and 2B show changes in comfort levels assessed by the VAS scale or anxiolysis and ASC under the

various conditions of *Shirodhara*. The safety of the methods should be taken into account, because, in some extreme conditions, some subjects suffered from headache, chill, slight chill, or other discomfort, as shown in Table 3. The screening tests showed us that the most comfortable and safest conditions were a 30-minute duration at 39°C at a oil flow rate of 2.3 L/min. The diameter of the dripping oil nozzle was 8 × 8 mm. Other fixed conditions were the moving speed of the dripping nozzle, set at 1.5 cm/sec, and the height of the nozzle, being set at 20 cm above the forehead. The pattern of dripping comprised temple, horizontal, and vertical movements, two times of each 5-minute movement. Under these conditions, we compared the psychoneuroimmunologic changes brought about by *Shirodhara* and the control supine condition.

TABLE 5. COMPARISON OF CORRELATION COEFFICIENTS BETWEEN ANXIOLYSIS AND SKIN TEMPERATURE ELEVATION IN CONTROL AND TREATMENT GROUPS

	Anxiolysis (control)		Anxiolysis (experiment)	
Increase of skin temp. (hand: former half)	0.03	0.92	0.26	0.32
Increase of skin temp. (hand: latter half)	-0.01	0.97	-0.01	0.97
Increase of skin temp. (hand: after <i>Shirodhara</i> )	0.04	0.90	-0.07	0.81
Increase of skin temp. (foot: former half)	0.49†	0.08	0.60**	0.01
Increase of skin temp. (foot: latter half)	0.37	0.19	0.59*	0.02
Increase of skin temp. (foot: after <i>Shirodhara</i> )	0.24	0.40	0.58*	0.02

† $p < 0.1$ , \* $p < 0.05$ , \*\* $p < 0.01$ ,  $N = 16$ , Pearson's correlation coefficient).

No mark means no significant correlation between scores of each domain and the increase in skin temperature. Anxiolysis was determined by the state anxiety change from before to after *Shirodhara*. The former half was the 15 minutes after starting *Shirodhara*, and the later half was the last 15 minutes.

Comparison between *Shirodhara* and control. (1) *ASC and State Anxiety*. The subjects after *Shirodhara* treatment showed decreased levels of state anxiety, and had higher ASC scores than those in the control supine condition (Figs. 3 and 4). (2) *Changes in the skin temperature*. The skin temperature of the dorsal aspects of the right foot, but not of the right hand, increased more in the *Shirodhara* treatment than in the control

condition (Fig. 5;  $p < 0.1$ ). The changes in foot temperature on *Shirodhara* showed a different tendency, while the hand temperature showed changes similar to those of the control. (3) *Changes of catecholamine*. Plasma noradrenaline levels in the *Shirodhara* treatment group were decreased significantly more than in the control ( $p < 0.05$ ,  $N = 16$ , paired *t*-test, Fig. 6), while neither plasma adrenaline nor plasma dopamine

TABLE 6A. CORRELATION BETWEEN PSYCHOLOGIC PARAMETERS AND PLASMA OR URINARY CATECHOLAMINE

<i>Control supine position</i>	<i>Axiolysis</i>		<i>ASC average</i>		<i>Space</i>		<i>Body sense</i>		<i>Trance</i>		<i>Passive</i>	
Serum TRH after experiment	0.35	0.19	0.34	0.20	-0.53*	0.04	-0.46	0.08	-0.37	0.16	-0.31	0.24
Plasma noradrenaline after experiment	-0.58*	0.05	0.29	0.35	0.44	0.15	0.34	0.28	0.37	0.23	0.31	0.32
Plasma dopamine after exp.	-0.22	0.50	0.34	0.28	0.35	0.27	0.40	0.20	0.27	0.39	0.43	0.17
Change ratio of serum TRH	0.14	0.74	-0.55	0.16	-0.55	0.15	-0.49	0.22	-0.56	0.15	-0.50	0.21
Change ratio of PMN/Ly ratio	-0.36	0.21	0.30	0.30	0.35	0.21	0.32	0.26	0.23	0.42	0.15	0.62

<i>Experiment</i>	<i>Axiolysis</i>		<i>ASC average</i>		<i>Space</i>		<i>Body sense</i>		<i>Trance</i>		<i>Passive</i>	
Serum TRH after experiment	-0.23	0.39	-0.40	0.13	-0.47	0.07	-0.09	0.75	-0.24	0.37	-0.12	0.66
Plasma noradrenaline after experiment	0.19	0.48	0.15	0.57	0.12	0.66	0.34	0.19	-0.02	0.95	0.28	0.30
Plasma dopamine after exp.	0.03	0.92	0.53*	0.03	-0.35	0.18	-0.42	0.11	-0.35	0.19	-0.44	0.09
Change ratio of serum TRH	-0.54	0.27	0.83*	0.04	-0.71	0.12	-0.32	0.54	-0.67	0.15	-0.14	0.78
Change ratio of PMN/Ly ratio	-0.36	0.17	-0.44	0.09	-0.34	0.20	-0.56*	0.02	-0.31	0.24	-0.43	0.09

\* $p < 0.05$ , by Spearman's correlation coefficient. No mark means no significant correlation between physiologic parameters and plasma or urinary catecholamine and axiolysis or scores of altered consciousness (ASC).

TRH, thyrotropin-releasing hormone; Space, loss of space perception; Body sense, loss of body sense; Trance, subject is enraptured; Passive, passiveness; PMN, polymorphonuclear neutrophils; Ly, lymphocytes.

TABLE 6B. CORRELATION BETWEEN PSYCHOLOGIC PARAMETERS AND PLASMA OR URINARY CATECHOLAMINE

<i>Control supine position</i>	<i>Sub.-Obj.</i>		<i>Time</i>		<i>Speech</i>		<i>Conc.</i>		<i>Moment.</i>		<i>C.C.</i>	
Serum TRH after experiment	-0.43	0.09	-0.21	0.43	-0.21	0.45	0.00	0.99	-0.45	0.08	-0.50*	0.05
Plasma dopamine after experiment	0.32	0.32	0.14	0.67	-0.07	0.83	0.18	0.58	0.20	0.54	0.22	0.49
Change ratio of serum TRH	-0.66	0.08	-0.71*	0.05	-0.33	0.42	-0.52	0.18	-0.59	0.13	-0.60	0.11
Change ratio of plasma dopamine	0.08	0.80	-0.18	0.58	-0.08	0.79	-0.20	0.53	-0.10	0.76	0.10	0.77
Change ratio of PMN/Ly ratio	0.23	0.42	0.21	0.47	0.09	0.76	0.13	0.65	0.46	0.09	0.20	0.49

<i>Experiment</i>	<i>Sub.-Obj.</i>		<i>Time</i>		<i>Speech</i>		<i>Conc.</i>		<i>Moment.</i>		<i>C.C.</i>	
Serum TRH after experiment	-0.29	0.28	-0.50*	0.05	-0.20	0.46	-0.52*	0.04	-0.10	0.72	0.06	0.83
Plasma dopamine after experiment	-0.36	0.18	-0.44	0.09	-0.70**	0.00	-0.16	0.56	-0.39	0.14	-0.48	0.06
Change ratio of serum TRH	-0.50	0.31	-0.77	0.07	-0.93**	0.01	-0.90*	0.01	0.35	0.50	0.09	0.87
Change ratio of plasma dopamine	-0.13	0.63	-0.24	0.38	-0.50*	0.05	-0.01	0.96	-0.38	0.15	-0.30	0.26
Change ratio of PMN/Ly ratio	-0.50*	0.05	-0.43	0.10	-0.44	0.09	-0.16	0.54	-0.01	0.97	-0.28	0.29

\* $p < 0.05$ , \*\* $p < 0.01$  by Spearman's correlation coefficient (c.c). No mark means no significant correlation between physiologic parameters and plasma or urinary catecholamine and axiolysis or scores of altered consciousness (ASC).

Sub.-Obj., subjectivity and objectivity; Time, loss of time perception; Speech, loss of speech sense; Conc., concentration; Moment., "Momentariness"; TRH, thyrotropin-releasing hormone; PMN, polymorphonuclear neutrophils; Ly, lymphocytes.



levels showed a significant difference. (4) *Changes of urinary serotonin.* Urinary serotonin excretion just after and 1 hour after finishing *Shirodhara* was decreased significantly more than in the control condition ( $p < 0.05$ ,  $N = 16$ , paired  $t$ -test, Fig. 7). (5) *Changes in NK cell activity and PMN/lymph ratio of peripheral blood.* NK cell activity decreased significantly in the control condition ( $p < 0.05$ ,  $N = 16$ , paired  $t$ -test, Fig. 8, right), while there were no changes in the *Shirodhara* group. However, there was no significant difference by two-way ANOVA. The PMN/lymphocyte ratio maintained the same levels in the control condition, while it decreased significantly on *Shirodhara* treatment ( $p < 0.05$ ,  $N = 16$ , paired  $t$ -test, Fig. 8, left). These changes were not significantly different by two-way ANOVA.

Comparison of the correlation between parameters in *Shirodhara* and control. (1) *Correlation between ASC and anxiolysis.* The correlations between ASC scores of all 10 domains and the anxiolytic effect were significantly higher in the Trance experience of *Shirodhara*, while there was no significant correlation in the control condition ( $r = 0.52$ ,  $p < 0.05$  Spearman's correlation coefficient, Table 4). Regression coefficients of the ASC score (Trance) and anxiolysis were significantly different between control and treatment groups on the assumption that ASC scores are parametric values ( $p < 0.05$ , ANCOVA, Table 4). (2) *Correlation between ASC or anxiolysis and skin temperature.* Anxiolysis (% reduction of state anxiety) and the increase of the skin temperature of dorsal aspect of the foot, not hand, were significantly correlated in *Shirodhara* ( $r = 0.58$ – $0.60$ ,  $p < 0.05$ ,  $N = 16$ , Pearson's correlation coefficient, Table 5). The correlation between the anxiolytic effect and increase in skin temperature was only significant in the foot skin. However, the regression coefficient between anxiolysis and the foot skin temperature increase was not significantly different ( $p > 0.05$ , ANCOVA, Table 4). An increase of the mean skin temperature of the foot in the latter half of *Shirodhara*, not in the control, was also correlated with the ASC score, especially in the Trance experience (Table 4). The regression coefficients of the ASC score (Trance) and foot skin temperature increase were significantly different ( $p < 0.01$ , ANCOVA, Table 4). (3) *Correlation between ASC or anxiolysis and NK cell activity after Shirodhara.* Anxiolysis and ASC, especially Trance experience, were well correlated with NK cell activity after *Shirodhara* ( $r = 0.33$ ,  $0.56$ ,  $p < 0.05$ , Table 4). The regression coefficients between the ASC score (Trance) or anxiolysis and NK cell activity were significantly different ( $p < 0.05$  in both, ANCOVA, Table 4). (4) *Correlation between ASC or anxiolysis and catecholamines, TRH, and urinary serotonin.* Tables 6a and 6b show the correlation between psychologic parameters and plasma catecholamine or urinary serotonin obtained by Spearman's method. In the control supine condition, not *Shirodhara*, scores of ASC such as Space and Cosmic Consciousness (C.C) (Table 1) were correlated with the TRH level ( $r = -0.53$ ,  $-0.50$ ,  $p < 0.05$ , respectively). The ASC score (Time) was correlated with the TRH level and TRH change ( $r = -0.56$ ,  $-0.71$ ,  $p < 0.05$ , respectively). However, only in the *Shirodhara* treatment was the average score of ASC and score of Speech negatively correlated with the plasma dopamine level and change of plasma dopamine ( $r = -0.53$ ,  $-0.70$ ,  $-0.50$ ,  $p < 0.05$ , respectively). Furthermore, the average ASC score, and scores of Speech and Concentration (Conc.) were

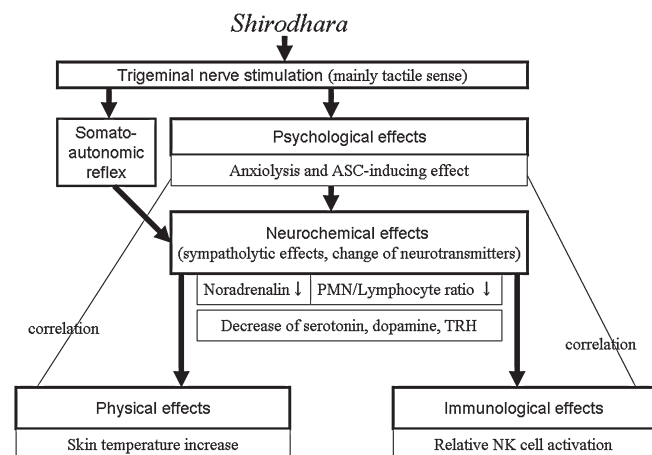
negatively correlated with the TRH-change ratio ( $r = -0.83$ ,  $-0.93$ ,  $-0.90$ ,  $p < 0.05$ , respectively). Scores of ASC for Time and Conc. were also negatively correlated with the TRH level ( $r = -0.50$ ,  $-0.52$ ,  $p < 0.05$ , respectively). In the control study, anxiolysis was negatively correlated with the plasma noradrenaline level ( $r = -0.58$ ,  $p < 0.05$ , Pearson's correlation coefficient). However, this correlation was not obtained on *Shirodhara* treatment. Plasma adrenaline level and change ratio of plasma adrenaline and noradrenaline were not correlated with any domains of ASC or anxiolysis either in the control or *Shirodhara* treatments.

The regression coefficients between ASC scores or anxiolysis and various parameters were not significantly different ( $p > 0.1$  in all, ANCOVA).

## Discussion and Conclusions

The robotic oil-drip system in this study facilitated a completely reproducible method for *Shirodhara*. The regulated modes of treatment were maintained for all subjects during *Shirodhara*. Differences in effects depending on the oil temperature, oil flow rate, and length of treatment were elucidated with this robotic system. This is the benefit of employing a robotic *Shirodhara* regulator compared to the usual hanging pot with a hole in the bottom, which is unable to provide the same regulated treatment to all subjects. We adopted the most comfortable and safest conditions of *Shirodhara* to study psychoimmunologic effects.

Psychologic changes in this study supported the anxiolytic and ASC-inducing effects of *Shirodhara*. The anxiolytic effect of *Panchakarma* reported by H.M. Sharma must be explained partly by this anxiolytic effect of *Shirodhara*. Anxiolysis induced by *Shirodhara* was positively correlated with NK cell activity after *Shirodhara* and elevation of the foot skin temperature. Furthermore, Trance experience induced by *Shi-*



**FIG. 9.** Suspended mechanism of the action of *Shirodhara*-induced psychologic effects as well as neural, immunological, and physical changes. An increase of the foot skin temperature and relative elevation of natural killer (NK) cell activity by *Shirodhara* treatment may be related with the autonomic nervous suppression secondarily induced by the psychologic effects of *Shirodhara*. ASC, state of consciousness; PMN, polymorphonuclear neutrophils; TRH, thyrotropin-releasing hormone.

*rodhara* was positively correlated with anxiolysis, NK cell activity, and elevation of the foot skin temperature. These results supported the psychoneuroimmunologic effects of *Shirodhara*.

The biochemical changes showed the significant suppression of noradrenaline not adrenaline, and suppression of urinary serotonin and the decrease of the PMN/lymphocyte ratio only in *Shirodhara*. These results reflect the sympatholytic effect of *Shirodhara*, especially suppression of the  $\alpha$ -receptor, which works with noradrenaline. Vaitl et al. reported that ASC induced a sympathetic suppression rather than parasympathetic activation.<sup>10</sup> ASC induced by *Shirodhara* may cause the same sympathetic nervous suppression. Irwin et al. reported that the sympathetic nervous system mediates the suppression of NK cytotoxicity.<sup>13</sup> An increase of the foot skin temperature and relative elevation of NK cell activity by *Shirodhara* treatment may be related with this sympathetic nervous suppression, secondarily induced by the psychologic effects or somato-autonomic nervous reflex<sup>14</sup> during *Shirodhara*.<sup>13,15</sup> The negative correlation of the TRH change or dopamine with some domains of ASC may also be related to the sympathetic suppression because the autonomic nervous system is linked to the depression of various neurotransmitter secretions such as TRH and dopamines.<sup>16</sup>

In our study, the anxiolysis and the mean skin temperature of the dorsal aspects of the feet, not hands, were correlated (Table 5). Although the same neural linkage between the central nervous system and hand or foot skin has been drawn, innervation by the autonomic nervous system of the hand may not be the same as in the foot. We obtained results whereby pressure stimulation of hands and feet for 15 minutes showed the opposite reaction to heart rate variability.<sup>17</sup> Further research is needed to elucidate hand-foot differences (Fig. 9).

Figure 9 summarizes the psychoneuroimmunologic changes in this study of *Shirodhara*. Warm, plain sesame oil starts the action from the tactile stimulation of the skin innervated by the first branch of the trigeminal nerve. It is possible that the impulses are transmitted to the thalamus through the principal nucleus and forwarded to the cerebral cortex. The impulses from the forehead cause a somato-autonomic reflex,<sup>14</sup> and changes in levels of various neurotransmitters including, serotonin, TRH, and catecholamine, resulting in sympathetic suppression and physioimmunologic changes of peripheral circulation and NK cell activity. It is worth doing further investigation to elucidate the effects of *Shirodhara* or *Panchakarma* of Ayurveda.

### Disclosure Statement

This research did not involve competing financial interests.

### References

- Sharma AK. The *Panchakarma* Treatment of Ayurveda Including *Keraliya Panchakarma*. Delhi: Sri Satguru Publications, 2002.
- Sharma HM, Nidich SI, Sands D, Smith DE. Improvement in the cardiovascular risk factors through *Panchakarma* purification procedures. *J Res Edu Indi Med* 1993;12:3–13.
- Uebaba K, Xu F, Ogawa H, et al. Using a Healing Robot for the Scientific Study of *Shirodhara*. *IEEE Eng Med Biol Mag* 2005;March/April:69–78.
- Uebaba K, Xu FH, Tatsuse T, Hisajima T. Psychological mechanism of Traditional healing technique performed by the healing robot through the life information field. *J Int Soc Life Info Sci* 2004;22:169–178.
- Bhagwan D. *Massage Therapy in Ayurveda*. New Delhi: Concept Publishing Company, 1992.
- Devaraj TL. The *Panchakarma* Treatment of Ayurveda. Bangalore: Dhanvantari Oriental Publications, 1980.
- Spielberger CD. Theory and research on anxiety. In: Spielberger CD, editor. *Anxiety and Behavior*. New York: Academic Press, 1966:24–43.
- Saito T. *Researches on Altered State of Consciousness (ASC)*. Kyoto: Shouraisha, 1981.
- Saito T. Psychological process in the altered state of consciousness and Zen experience. *Ritsumaikan Hum Sci Res* 2003;5:45–53.
- Vaitl D, Birbaumer N, Gruzelier J, et al. Psychobiology of altered states of consciousness. *Psychol Bull* 2005;131:98–127.
- Bundzen PV, Korotkov KG, Unesthal LE. Altered states of consciousness: Review of experimental data obtained with a multiple techniques approach. *J Altern Complement Med* 2002;8:153–165.
- Suzuki S, Toyabe S, Moroda T, et al. Circadian rhythm of leukocytes and lymphocytes subsets and its possible correlation with the function of autonomic nervous system. *Clin Exp Immunol* 1997;110:500–508.
- Irwin M, Hauger RL, Jones L, et al. Sympathetic nervous system mediates central corticotrophin-releasing factor induced suppression of natural killer cytotoxicity. *J Pharmacol Exp Ther* 1990;255:101–107.
- Sato A. Neural mechanisms of autonomic responses elicited by somatic sensory stimulation. *Neurosci Behav Physiol* 1997;27:610–621.
- Fecho K, Maslonek KA, Dykstra LA, Lysle DT. Alterations of immune status induced by the sympathetic nervous system: Immunomodulatory effects of DMPP alone and in combination with morphine. *Brain Behav Immun* 1993;7:253–270.
- al-Damluji S. Adrenergic control of the secretion of anterior pituitary hormones. *Baillieres Clin Endocrinol Metab* 1993;7:355–392.
- Uebaba K, Xu FH, Tagawa M, Asakura R. Differences of circulatory, respiratory and autonomic nervous changes by the pressure stimulation to hand or foot. *Eastern Med* 2004;20:1–22.

Address reprint requests to:

Kazuo Uebaba, M.D., Ph.D.

International Research Center for Traditional Medicine  
of Toyama Prefecture  
151 Tomosugi  
Toyama, Toyama Prefecture, 939-8224  
Japan

E-mail: uebaba@inm.u-toyama.ac.jp

Copyright of *Journal of Alternative & Complementary Medicine* is the property of Mary Ann Liebert, Inc. and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.