Autonomic Neuroscience: Basic and Clinical 158 (2010) 105–110

Contents lists available at ScienceDirect

Autonomic Neuroscience: Basic and Clinical

journal homepage: www.elsevier.com/locate/autneu

Physiological responses to touch massage in healthy volunteers

L. Lindgren [a,b,*], S. Rundgren [a], O. Winsö [b], S. Lehtipalo [b], U. Wiklund [c], M. Karlsson [c], H. Stenlund [d], C. Jacobsson [a], C. Brulin [a]

[a] Department of Nursing, Umeå University, Sweden
[b] Department of Surgical and Perioperative Sciences, Anesthesiology and Intensive Care, Umeå University, Sweden
[c] Department of Biomedical Engineering, Umeå University, Sweden
[d] Department of Public Health and Clinical Medicine, Umeå University, Sweden

ARTICLE INFO

Article history:
Received 29 March 2010
Received in revised form 11 June 2010
Accepted 22 June 2010

Keywords:
Touch
Massage
Autonomic nervous system
Heart rate variability
Saliva cortisol
Glucose
Insulin
Microdialysis

ABSTRACT

Objectives: To evaluate effects of touch massage (TM) on stress responses in healthy volunteers.
Methods: A crossover design including twenty-two (mean age = 28.2) healthy volunteers (11 male and 11 female) cardiac autonomic tone was measured by heart rate (HR) and heart rate variability (HRV). Stress hormone levels (cortisol) were followed in saliva. We also measured blood glucose and serum insulin. Extracellular (ECV) levels of glucose, lactate, pyruvate and glycerol were followed using the microdialysis technique (MD). TM was performed on hands and feet for 80 min, during control, participants rested in the same setting. Data were collected before, during, and after TM and at rest. Saliva cortisol, serum glucose, and serum insulin were collected before, immediately following, and 1 h after intervention or control, respectively.
Results: After 5 min TM, HR decreased significantly, indicating a reduced stress response. Total HRV and all HRV components decreased during intervention. Saliva cortisol and insulin levels decreased significantly after intervention, while serum glucose levels remained stable. A similar, though less prominent, pattern was seen during the control situation. Only minor changes were observed in ECV levels of glucose (a decrease) and lactate (an increase). No significant alterations were observed in glycerol or pyruvate levels throughout the study. There were no significant differences between groups in ECV concentrations of analyzed substances.
Conclusions: In healthy volunteers, TM decreased sympathetic nervous activity, leading to decreased overall autonomic activity where parasympathetic nervous activity also decreased, thereby maintaining the autonomic balance.

1. Introduction

In clinical practice, in order to reduce stress, anxiety and pain among patients cared for in hospitals, sedatives and analgesics are commonly used which, however, can delay discharge due to secondary effects of the drugs. For this reason and in order to decrease stress, anxiety and pain among patients, touch massage (TM) is sometimes used as a complementary treatment. When patients have been given TM, changes in blood pressure, heart rate, and respiratory frequency have been observed. These clinical observations indicate that TM influences the autonomic nervous system and alters stress response. Despite recent interest in this area, only few explanatory models of the effect of massage on stress reactions have been presented (Moraska et al., 2008). One theory, however, is that moderate massage may increase activity in the parasympathetic nervous system by activating pressure receptors in the skin (Diego and Field, 2009); another is that massage contributes to the release of oxytocin (Uvnas-Moberg, 1998).

There are several different massage techniques, some involving the muscles, others involving the skin. The Swedish Council on Technology Assessment in Health care uses the term TM to cover different forms of light massage involving the skin (Swedish National Council on Technology Assessment, 2002). Therefore, in the following text we use TM as a comprehensive concept to describe light, gentle, tactile massage. These forms of massage are characterized by gentle touches of the skin involving light pressure effleurage and long, calm stroking movements intended to increase the patients' or relatives' well-being (Cronfalk et al., 2009), pleasure (Bergsten et al., 2005), and relaxation (Billhult and Maatta, 2009; Goodfellow, 2003). The emotional aspects of touch may be explained by positive feelings elicited by activating specific C-tactile afferents in the skin that signal to areas in the brain involved in positive emotions (Olausson et al., 2008).

* Corresponding author. Department of Nursing, Umeå University, Sweden.
E-mail address: lenita.lindgren@nurs.umu.se (L. Lindgren).

1566-0702/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.autneu.2010.06.011

In a study evaluating physiological responses to TM, breast cancer patients who received TM showed no subsequent significant long-term effects in either saliva cortisol levels or serum oxytocin levels (Billhult et al., 2008). In addition, there were no significant differences in anxiety levels after TM (Billhult et al., 2008). However, after full-body TM treatment, short-term decreases were found in both heart rate and systolic blood pressure (Billhult et al., 2009).

Stress reactions are generally a consequence of the disease itself and often necessary for survival. However, during demanding and threatening situations evoking feelings of insecurity, pain, and fear, stress response is also triggered by psychological factors (Field et al., 2008; Uhlig and Kallus, 2004; Vanhorebeek and Van den Berghe, 2006). Therefore, in clinical practice, it is a challenge to find and develop effective treatments to reduce such stress reactions. The human body has an enormous capacity to maintain homeostasis, even through stressful events, and of achieving homeostasis through a process of physiological or behavioral change called allostasis. Nevertheless, if stress is sustained over a long period allostasis cannot be maintained and a homeostatic imbalance gradually develops within and between different vital organ systems, inducing complex reactions known as allostatic overload (McEwen, 2006; Thayer and Brosschot, 2005; Thayer and Sternberg, 2006). Pharmacological treatment to reduce the consequences of stress reactions could in fact worsen the situation through adverse interactions between the particular drugs used and different physiological systems (McEwen, 2006). For this reason, it is important to find and evaluate additional methods such as massage to reduce and prevent stress. Yet, in spite of the fact that the use of TM has increased during the past decade, no systematic studies have been implemented to study the efficacy of such treatment.

The aim of this study was to evaluate the short-term effects of TM on stress response, as measured by heart rate (HR), heart rate variability (HRV), saliva cortisol levels, and glucose metabolism in healthy volunteers, in order to test the hypothesis that TM reduces stress response by increasing parasympathetic nervous activity.

2. Materials and method

In this study we used a crossover design. Thus, all participants served as their own controls. A sequential number was assigned to 22 opaque envelopes, which contained the assigned treatment group per participant. In this study participants during the intervention occasion are called the intervention group (IG) and during the control occasion are called the control group (CG) (Fig. 1). The study procedure is schematically described in Fig. 2. After approval from the Regional Ethical Review Board in Umeå (Dnr 07-183M), the study was carried out over 8 months in 2008.

2.1. Participants

In response to advertisements in local newspapers and bulletin boards and to verbal requests, 63 volunteers applied for participation. Participants were excluded from the study if they used tobacco, took medication (with the exception of one woman who used oral contraception), or had any diseases. Out of 36 included participants, 22 healthy volunteers (11 male and 11 female) were randomly selected. The sample size is based on a power calculation given significant ($P<.05$) differences in mean values for heart rate between the intervention group and the control group and 80% power. Based on power analysis, totally 4 patients in each group would be included. Participants (N = 22) were randomly selected to the IG (n = 11) or the CG (n = 11) by the two first authors; mean age was 28.2 years (SD 6.36) and mean body mass index (BMI) was 23.2 (SD 2.72).

2.2. Intervention

Subjects in the IG received TM of the hands and feet in a specific order and in a relaxed setting. The massage pressure was about 2.5 N and the velocity was 1–5 cm/s. TM consisted of stroking movements on the ventral and dorsal side of hands and feet along with circular movements on each finger and toe. TM was performed for 80 min in the following order: 20 min each on the left hand, the right hand, the right foot, and the left foot. To make TM more pleasant, a combination of jojoba, sheabutter, sunflower, and vitamin E oil was used in the massage. TM was performed by six female specially trained and massage-educated staff members working in the intensive care unit in Umeå, Sweden. Two of the authors (LL and SR) gave TM in four out of 11 occasions. In the CG the participants rested in the same setting; the only difference between the occasions was whether or not the participants received TM. The massage force was measured by the same stroking movements as used in TM on a "dummy arm" equipped with force transducers. A 10 cm skin area was marked and stroking movement was time-kept in order to measure the velocity.

2.3. Measurements and analyses

To evaluate the effect of TM, several outcome variables were used, such as heart rate, heart rate variability, saliva cortisol, serum glucose, and insulin, as well as extracellular levels of glucose, lactate, pyruvate, and glycerol.

2.3.1. Heart rate and heart rate variability

The activity in the autonomic nervous system (both sympathetic and parasympathetic) was estimated based on analysis of heart rate variability (HRV), which refers to the beat-to-beat fluctuations in heart rate (HR). The parasympathetic nervous system can quickly and finely adjust the time instant for the next heart beat, whereas the sympathetic nervous system is a slower system for regulation of HR. This discrepancy in reactions creates variability within different frequency domains. The high frequency region (HF; 0.15–0.40 Hz) is mainly mediated by parasympathetic activity, whereas the low frequency region (LF; 0.04–0.15 Hz) is mediated by both sympathetic and parasympathetic activity. Fluctuations in the very low frequency region (VLF; ≤0.04 Hz) are not fully understood but have been

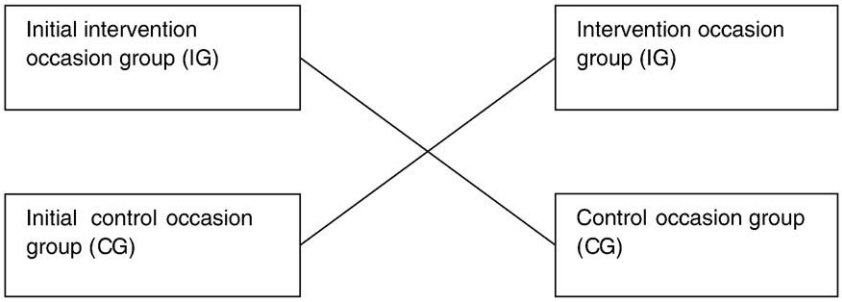

Fig. 1. Schematic model, describing the study design.

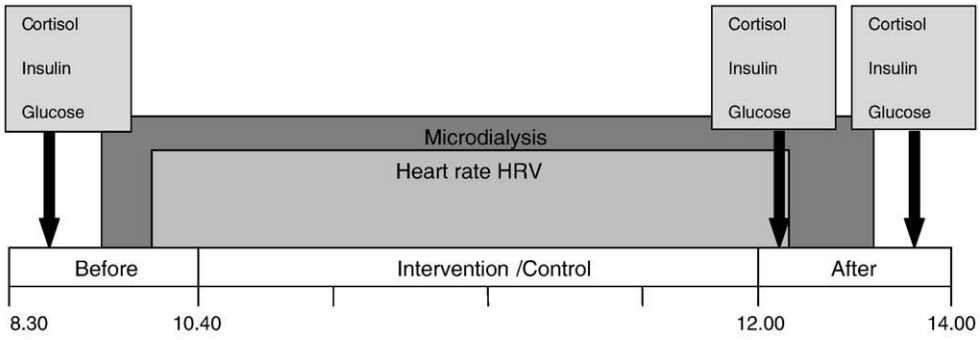

Fig. 2. Schematic model, describing the study procedure.

suggested to reflect thermoregulation and activity in the renin–angiotensin system. The LF/HF ratio reflects the sympatho/vagal balance (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996).

HRV was determined based on electrocardiography (ECG), recorded from five electrodes on the chest using a Marquette Solar 8000M monitor (GE Healthcare, Milwaukee, USA). Data were stored on a computer for further analysis using custom made software.

Mean values of HR and HRV indices were calculated for 5-min baseline segment while the subject was resting in the supine position. Participants were lying in a supine position 5 min before sampling the baseline data. During the massage HRV parameters were determined for successive 5-min segments starting every 20 min. Finally, HRV was calculated for the first 5-min period after massage.

HRV was analyzed by power spectrum analysis of interbeat intervals. RR intervals were converted to a time series by cubic spline interpolation, followed by resampling at 2.4 Hz. Ectopic beats and missing data points were replaced by interpolation. The power spectral density was estimated by auto-regressive modelling using the Burg-algorithm with 30 parameters. The following HRV indices were calculated for each 5-min segment: total power in the frequency region 0.003–0.50 Hz (Ptot); power of the very low frequency (P_{VLF}), low frequency (P_{LF}) and high frequency (P_{HF}) components. All HRV analyses were performed using Matlab (Mathworks Inc., Natick, MA, USA).

2.3.2. Saliva cortisol

To measure activity in the Hypothalamic–Pituitary–Adrenal (HPA) axis saliva samples for cortisol were collected in saliva collection tubes (Salivette, Sarstedt, Nümbrecht, Germany) and analyzed using a Spectria Cortisol RIA (Orion Diagnostica, Finland). All analyses were conducted in the Clinical Chemical Laboratory at the University Hospital, Umeå, Sweden.

2.3.3. Serum glucose and insulin

For measurements of serum glucose and serum insulin, a peripheral venous catheter (18 G 32 mm Smiths Medical, Italy) was inserted in the right arm for blood samples. Glucose levels in serum were analyzed using Ortho Vitros GLU slides on a Vitros 5.1 FS analyzer. Insulin levels in serum were analyzed using Roche Elecsys Insulin reagents on a Modular E170 analyzer. All analyses were conducted in the Clinical Chemical Laboratory at the University Hospital, Umeå, Sweden.

2.3.4. Extracellular levels of glucose, lactate, pyruvate, and glycerol

For determination of glucose, lactate, pyruvate, and glycerol two microdialysis catheters (CMA 60, CMA Sweden) with a membrane length of 30 mm and a cut off of 20 kDa were inserted (on the left and right side) in the abdominal subcutaneous tissue for collection of interstitial samples. The catheters were connected to a microdialysis pump (CMA 107, CMA Sweden) and perfused with Ringer solution at a rate of 1.0 μl/min. Microvials (CMA, Sweden) were changed every 20 min. The first vial was always discarded. The dialysates in the microvials were stored directly in a cold bag and later in a refrigerator. The samples were analyzed on the following day for glucose, lactate, pyruvate, and glycerol concentrations using enzymatic reagents followed by colorimetic analysis (CMA 600, CMA Sweden).

2.4. Procedure

Every session of the study took place at the same time of day (Fig. 2). Each participant arrived at 0830 h (8:30 a.m.) and was prepared with microdialysis catheters and a peripheral venous catheter. Blood samples for glucose and insulin analyses and the saliva sample for determining cortisol levels were collected at this time. Thereafter, the participant rested in a waiting room. At 1020 h (10:20 a.m.) participants in both groups were shown to a dark room with candles and calm music and placed in the supine position. The temperature in the room was between 21 °C and 22.5 °C (70–73 °F) in all sessions. ECG electrodes were placed on the chest. TM was performed in IG from 1040 h (10:40 a.m.) to 1200 (12:00 p.m.) There were no conversations during the study, only a few times answering participants' questions. After the intervention in IG or rest in CG the participants rested for additional 20 min. Blood and saliva samples were collected at 1220 h (12:20 p.m.) and 0120 h (1.20 p.m.). ECG registrations were carried out before, during, and at the end of the intervention or rest period at 1220.

2.5. Statistical analysis

Kolmogorov–Smirnov test was used to test for normality of variables. Data for HR, HRV, serum glucose, and insulin were positively skewed and were therefore log-transformed before analysis. Values are given as mean (M) and standard deviation (SD) before transformation, except for HRV data that are presented as log-transformed values. Repeated measures ANOVA were used to analyze variables before and during as well as follow up measurements. Comparisons versus baseline were done using a simple contrast. Paired sample *t*-test was used to test for differences between IG and CG at each time point. Data from the microdialysis samples (glucose, lactate, pyruvate, and glycerol) were negatively skewed and therefore Wilcoxon signed rank test was used. To control for differences in glucose, lactate, pyruvate, and glycerol over time in both sessions, data from the microdialysis at every time point was controlled against baseline levels (baseline-time2, baseline-time3, etc). To test for differences between IG and OG, data at each time point was analyzed using Wilcoxon signed rank test. Significance was set at $P<0.05$. The statistical analyses were performed with SPSS software (version 17.0, SPSS Inc., Chicago IL, USA).

3. Results

There were no significant differences between those who were randomized to the IG and those who were randomized to the CG in any baseline data (HR, HRV components, saliva cortisol, serum glucose, serum insulin and extracellular ECV glucose, lactate, pyruvate, and glycerol) (Table 1; Fig. 3).

3.1. HR

For HR and HRV data, five participants were excluded throughout the study protocol due to arrhythmias, but included in analyses of other parameters. According to the trend analysis there was an initial decrease in heart rate after 5 min of touch massage compared with baseline value ($P=0.003$) in the IG. In both groups there was a significant decrease over 65 min, and this decrease was significantly more pronounced in the IG (Fig. 3). After termination of touch massage and rest, HR increased in both groups. Individual profiles for HR data displayed a similar pattern as the mean profiles.

3.2. HRV

Over time, total HRV showed a significant decrease from baseline value after 5 min of touch massage ($P<0.001$) and throughout the intervention (Fig. 3). In the CG there was a significant decrease only after 25 min rest ($P=0.005$). The biphasic pattern in total HRV was similar to that in HR.

In the IG, the trend analysis for the HF component showed significant decrease after 5 min ($P=0.008$). This decrease continued for 45 min of touch massage (Fig. 3). There was no initial decrease in the HF component in the CG, however, a significant decrease was shown by the end of the session ($P=0.023$).

During intervention, the LF component decreased significantly from the baseline level ($P<0.001$) after 5 min and continued to decrease for 45 min (Fig. 3). In the CG there were no such differences from baseline levels in the LF component.

The VLF component decreased in a biphasic pattern similar to those seen for the other HRV and HR components in both groups. In the IG the decrease in the VLF component from the baseline level was significant during the whole session (Fig. 3), while in the control group significant decreases occurred only after 25 min and at the end of the session.

The ratio between LF and HF showed a significant decrease from baseline levels to 10 min ($P=0.024$) in the IG. This decrease lasted for 20 min. After 10 min the ratio between LF and HF in the IG was close to one (close to zero in log scale), indicating balance between the LF and HF components. In the CG there was no significant difference from baseline level (Fig. 3).

Table 1
Saliva cortisol, serum insulin and serum glucose before, immediately after and 1 h after intervention/control. * denotes significant differences within groups from baseline value ($P<0.05$).

		Baseline[a]			After[a]				1 h after[a]			
Cortisol[b]	Massage	12.0	(8.8)	/21	5.7	(3.6)	/21	*	5.5	(5.1)	/20	*
Cortisol[b]	Control	13.9	(13.0)	/22	7.0	(7.8)	/22	*	5.6	(3.2)	/21	*
Insulin[c]	Massage	21.0	(17.8)	/22	5.5	(3.2)	/21	*	5.0	(4.3)	/22	*
Insulin[c]	Control	19.8	(13.7)	/22	5.1	(3.0)	/21	*	5.5	(6.5)	/22	*
Glucose[d]	Massage	4.4	(1.0)	/22	4.6	(0.5)	/21		4.4	(0.6)	/22	
Glucose[d]	Control	4.5	(0.8)	/22	4.6	(0.4)	/22		4.4	(0.6)	/21	

[a] Means (standard deviation)/number of individuals.
[b] nmol/L.
[c] mIU/L.
[d] mmol.

3.3. Saliva cortisol, serum insulin and serum glucose

There were significant reductions in saliva cortisol levels ($P<0.001$) and insulin levels ($P<0.001$) over time in both groups, but no significant differences between groups (Table 1). Glucose levels were stable over time in both IG and CG (Table 1) and no significant differences were found between the groups.

3.4. Microdialysis data

Extracellular (ECV) levels of glucose decreased and ECV levels of lactate increased significantly over time in the right catheter ($P=0.004$) ,but not in the left catheter, in both groups. No significant alterations were observed in glycerol or pyruvate levels during the study period. There were no significant differences between the groups in glucose, lactate, pyruvate, and glycerol levels.

4. Discussion

The main findings in this study were that after 5 min of TM there was a significant decrease in heart rate lasting for 65 min, indicating reduced stress response. Although the reduced heart rate indicates increased parasympathetic activity, both HRV and the HF component decreased during touch massage. The latter findings would normally be interpreted as decreased parasympathetic activity but may also reflect an overall down regulation in autonomic activity, as discussed below. Saliva cortisol and insulin levels decreased significantly after intervention, while the serum glucose level remained stable. A similar pattern, although less prominent was observed in the control group. The only significant differences between the groups were the decreases in heart rate after 45 min and in the HF component after 5 min.

In nursing care it is important to reduce stress reactions among patients. It is also necessary to evaluate treatments such as TM and understand the underlying mechanisms. Consequences of prolonged stress among patients can contribute to longer hospital stays or physical and psychological complications (Uhlig and Kallus, 2004). Despite the negative consequences of prolonged stress, normally the human body compensates for the negative effects by protecting itself. The autonomic nervous system, for instance, is characterized by increased sympathetic nervous activity when exposed to different stressors, while the parasympathetic nervous system is thought to have protecting effects (McEwen, 2008). This knowledge and an earlier massage study (Delaney et al., 2002) were arguments for our hypothesis that TM reduces stress response by increasing parasympathetic nervous activity.

One of the main findings in our study was that TM decreased both heart rate and HRV. The decreased HR can be caused by either increased parasympathetic nervous activity or decreased sympathetic nervous activity. However, note that HR reflects the average level in sympathetic and parasympathetic nervous activity, while HRV reflect changes in autonomic activity (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). Therefore, our results may be explained by TM decreasing sympathetic nervous activity, leading to a compensatory decrease in parasympathetic nervous activity, and thus an overall downregulation of autonomic activity (as indicated by decreased levels in LF, VLF and total HRV). This assumption is supported by the view that sympathetic and parasympathetic branches do not always act reciprocally, but may also act synergistically and complementarily (Paton et al., 2005; Wiklund et al., 2000). Therefore, our results explained by the synergistic model suit the homeostatic and allostasis concept, the human body trying to obtain balance.

Our results contrast with data from other massage studies (Delaney et al., 2002; Diego and Field, 2009; Takamoto et al., 2009). Diego and Field (2009) used HRV and found that parasympathetic

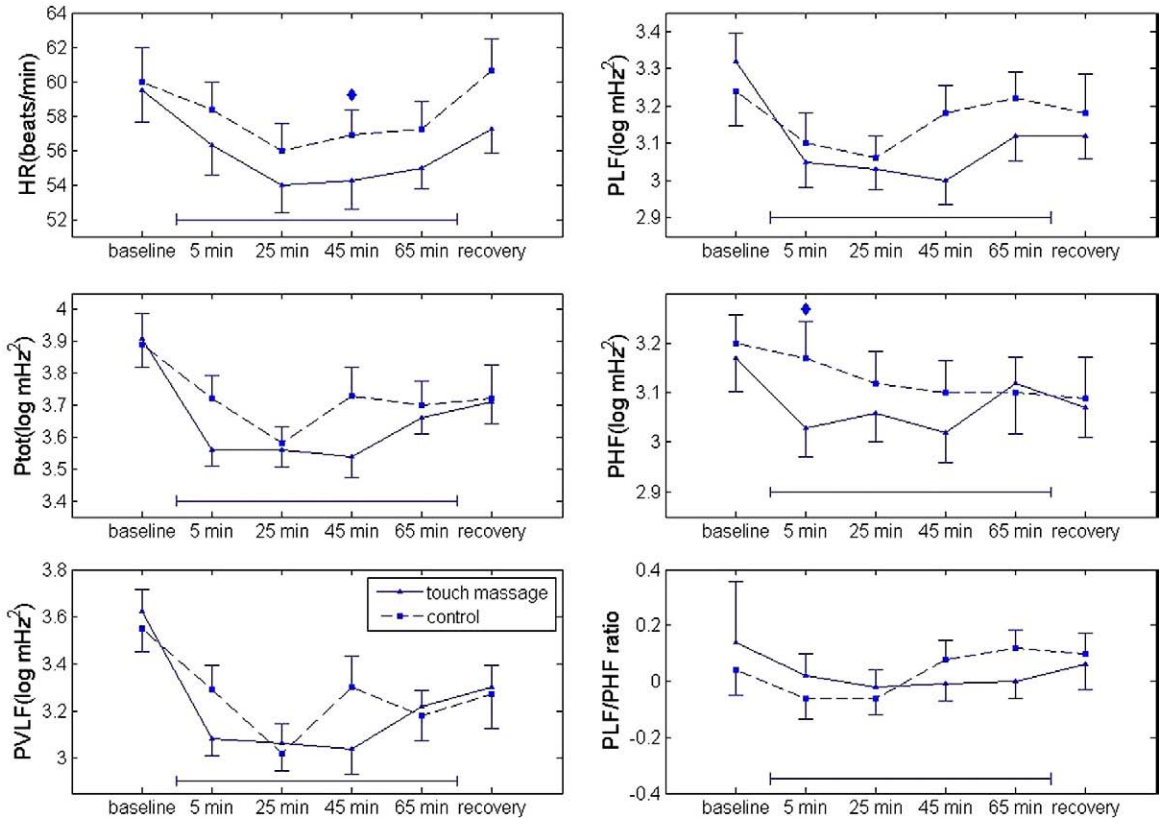

Fig. 3. Heart rate and HRV measured before, and every 20 min during intervention/control. Left panels: heart rate (top), total HRV (middle), and VLF component (bottom). Right panels: LF component reflecting sympathetic and parasympathetic activity (top), and HF component reflecting parasympathetic activity (middle), LF/HF ratio reflecting sympatho/vagal balance (bottom). The line under the curve represents intervention time. ✦ denotes differences between massage and control session ($P<0.05$).

nervous activity (HF component) increased in the moderate massage group, while it decreased in the light massage group. The authors concluded that moderate massage increased parasympathetic nervous activity while light massage increased sympathetic nervous activity. The decreased parasympathetic nervous activity (HF component) in their light massage group conforms with our data, however the LF/HF ratio increased in their light massage group, while in our study the LF/HF ratio decreased. In that article, heart rate and massage pressure were not presented, making further comparison difficult (Diego and Field, 2009). Delaney et al. (2002) and Takamoto et al. (2009) evaluated trigger point massage using HRV and they reported increased parasympathetic nervous activity (both total HRV and the HF component).

The Hypothalamic–Pituitary–Adrenal (HPA) axis is activated during stress and reacts on both external and internal stimuli. It is therefore logical to assume that its end product decreases with reductions in stress (Smyth et al., 1998). The end product in the HPA-axis, free cortisol, can easily be measured in saliva (Vining et al., 1983). Billhult and McVicar evaluated light massage through analyses of saliva cortisol levels as a marker and they found no significant differences between groups (Billhult et al., 2008, 2009; McVicar et al., 2007). This result is consistent with our data. However, there were no significant differences between the groups.

Activation of the autonomic nervous system and the HPA-axis influences glucose metabolism. The sympathetic nervous system and stress contribute to catabolic activity and the release of energy, while the parasympathetic nervous system works for anabolic activity and the storage of energy. Stress can therefore cause a metabolic syndrome with insulin resistance and increased blood glucose levels (Kyrou and Tsigos, 2007; Porges, 2007). Our hypothesis was that serum glucose levels would decrease during and after touch massage due to reduced stress response. Serum glucose levels were however almost constant over time in both sessions, while insulin levels decreased in both groups. Glucose metabolism has been evaluated by microdialysis technique in subcutaneous tissue in order to follow immediate changes on a cellular level (Ciechanowska et al., 2008). It has also been suggested that both the sympathetic and the parasympathetic nervous system innervate the subcutaneous tissue (Romijn and Fliers, 2005). Microdialysis data did not contribute any new insights in our study.

4.1. Methodological aspects

Crossover design has both advantages and disadvantages. The particular strength of this design in this study is that the same participants attended the two different "treatment" occasions, which eliminate between-subjects variability (Mills et al., 2009). Another advantage is the reduced number of participants needed. Garcia et al. (2004) concluded that a parallel design model needed 4 to 10 times more subjects than a similar crossover design to achieve the same power. Cleophas and Zwinderman (2002) have argued that crossover design is especially suitable when the different treatments are supposed to have positive additive effects. The disadvantage of using crossover design is the carryover effect from one occasion to the other (Mills et al., 2009). However, because there were no significant differences in any baseline parameters, we suggest that no major carryover effect influenced our results.

Difficulties in comparing massage studies include between-study variations in pressure, velocity, and body area. The choices of pressure and length of the massage in our study were made based on clinical experience and training in massage. In a study by Loken et al. (2009) brushing velocities of 1^{-10} cm s^{-1} was evaluated as most pleasant, however their force on the skin was 0.4 N compared with our force of about 2.5 N. In our future studies the force and velocity of the massage

will be maintained, but the time of the massage will be shortened because the heart rate established already after 5 min and remained stable for 65 min.

4.2. Study limitations

One problem with this study was the fact that music was included in both sessions. However, since music was used in both groups, the intervention—touch massage—served as a single outcome. The effect of calm music on the stress response is an interesting topic that needs further investigation. When evaluating massage it is impossible to blind the treatment. In massage studies there is always an interpersonal component that can affect the treatment. The concept of touch massage involves physical (McGlone et al., 2007), emotional (Olausson et al., 2008), cognitive (McCabe et al., 2008), social and interpersonal aspects (Gallace and Spence, 2010; Hertenstein et al., 2009; Morrison et al., 2010).

5. Conclusion

The main finding in our study was that touch massage reduces the heart rate by decreasing sympathetic nervous activity and evoking a compensatory decreased parasympathetic nervous activity in order to maintain autonomic balance. According to McEwen (2008) and the allostasis concept, it is important to find holistic complements to pharmaceutical therapies in order to achieve allostasis. Touch massage may therefore be used clinically to reduce stress response and preserve autonomic balance. A challenge in patient care, especially in nursing care, is to improve the status of the patient, and further, to use scientific evidence when treating and caring for patients. Another challenge is to evaluate methods not only through life experience but also using physiological evaluation and quality of life as an important outcome.

Acknowledgments

Financial support was provided by the Swedish Council for Working Life and Social Research and by Umeå University, Sweden. Thanks to the massage-educated staff members working in the intensive care unit in Umeå, Sweden.

References

Bergsten, U., Petersson, I.F., Arvidsson, B., 2005. Perception of tactile massage as a complement to other forms of pain relief in rheumatic disease. Musculoskelet. Care 3, 157–167.
Billhult, A., Maatta, S., 2009. Light pressure massage for patients with severe anxiety. Complement. Ther. Clin. Pract. 15, 96–101.
Billhult, A., Lindholm, C., Gunnarsson, R., Stener-Victorin, E., 2008. The effect of massage on cellular immunity, endocrine and psychological factors in women with breast cancer—a randomized controlled clinical trial. Auton. Neurosci. 140, 88–95.
Billhult, A., Lindholm, C., Gunnarsson, R., Stener-Victorin, E., 2009. The effect of massage on immune function and stress in women with breast cancer—a randomized controlled trial. Auton. Neurosci. 150, 111–115.
Ciechanowska, A., Ladyzynski, P., Wojcicki, J.M., Sabalinska, S., Krzymien, J., Pulawska, E., Karnafel, W., Foltynski, P., Kawiak, J., 2008. Microdialysis technique as a monitoring system for acute complications of diabetes. Artif. Organs 32, 45–51.
Cleophas, T.J., Zwinderman, A.H., 2002. Crossover studies with continuous variables: power analysis. Am. J. Ther. 9, 69–73.
Cronfalk, B.S., Strang, P., Ternestedt, B.M., Friedrichsen, M., 2009. The existential experiences of receiving soft tissue massage in palliative home care—an intervention. Support. Care Cancer 17, 1203–1211.
Delaney, J.P., Leong, K.S., Watkins, A., Brodie, D., 2002. The short-term effects of myofascial trigger point massage therapy on cardiac autonomic tone in healthy subjects. J. Adv. Nurs. 37, 364–371.
Diego, M.A., Field, T., 2009. Moderate pressure massage elicits a parasympathetic nervous system response. Int. J. Neurosci. 119, 630–638.
Field, K., Prinjha, S., Rowan, K., 2008. 'One patient amongst many': a qualitative analysis of intensive care unit patients' experiences of transferring to the general ward. Crit. Care 12, R21.
Gallace, A., Spence,, 2010. The science of interpersonal touch: an overview. Neurosci. Biobehav. Rev. 34, 246–259.
Garcia, R., Benet, M., Arnau, C., Cobo, E., 2004. Efficiency of the cross-over design: an empirical estimation. Stat. Med. 23, 3773–3780.
Goodfellow, L.M., 2003. The effects of therapeutic back massage on psychophysiologic variables and immune function in spouses of patients with cancer. Nurs. Res. 52, 318–328.
Hertenstein, M.J., Holmes, R., McCullough, M., Keltner, D., 2009. The communication of emotion via touch. Emotion 9, 566–573.
Kyrou, I., Tsigos, C., 2007. Stress mechanisms and metabolic complications. Horm. Metab. Res. 39, 430–438.
Loken, L.S., Wessberg, J., Morrison, I., McGlone, F., Olausson, H., 2009. Coding of pleasant touch by unmyelinated afferents in humans. Nat. Neurosci. 12, 547–548.
McCabe, C., Rolls, E.T., Bilderbeck, A., McGlone, F., 2008. Cognitive influences on the affective representation of touch and the sight of touch in the human brain. Soc. Cogn. Affect. Neurosci. 3, 97–108.
McEwen, B.S., 2006. Protective and damaging effects of stress mediators: central role of the brain. Dialogues Clin. Neurosci. 8, 367–381.
McEwen, B.S., 2008. Central effects of stress hormones in health and disease: understanding the protective and damaging effects of stress and stress mediators. Eur. J. Pharmacol. 583, 174–185.
McGlone, F., Vallbo, A.B., Olausson, H., Loken, L., Wessberg, J., 2007. Discriminative touch and emotional touch. Can. J. Exp. Psychol. 61, 173–183.
McVicar, A.J., Greenwood, C.R., Fewell, F., D'Arcy, V., Chandrasekharan, S., Alldridge, L.C., 2007. Evaluation of anxiety, salivary cortisol and melatonin secretion following reflexology treatment: a pilot study in healthy individuals. Complement. Ther. Clin. Pract. 13, 137–145.
Mills, E.J., Chan, A.W., Wu, P., Vail, A., Guyatt, G.H., Altman, D.G., 2009. Design, analysis, and presentation of crossover trials. Trials 10, 27.
Moraska, A., Pollini, R.A., Boulanger, K., Books, M.Z., Teitlebaum, L., 2008. Physiological adjustments to stress measures following massage therapy: a review of the literature. Evid Based Complement Alternat Med 7 (4), 409–418.
Morrison, I., Loken, L., Olausson, H., 2010. The skin as a social organ. Exp. Brain Res. 204 (3), 305–314.
Olausson, H., Wessberg, J., Morrison, I., McGlone, F., Vallbo, A., 2008. The neurophysiology of unmyelinated tactile afferents. Neurosci. Biobehav. Rev. 34, 185–191.
Paton, J.F., Boscan, P., Pickering, A.E., Nalivaiko, E., 2005. The yin and yang of cardiac autonomic control: vago-sympathetic interactions revisited. Brain Res. Brain Res. Rev. 49, 555–565.
Porges, S.W., 2007. The polyvagal perspective. Biol. Psychol. 74, 116–143.
Romijn, J.A., Fliers, E., 2005. Sympathetic and parasympathetic innervation of adipose tissue: metabolic implications. Curr. Opin. Clin. Nutr. Metab. Care 8, 440–444.
Smyth, J., Ockenfels, M.C., Porter, L., Kirschbaum, C., Hellhammer, D.H., Stone, A.A., 1998. Stressors and mood measured on a momentary basis are associated with salivary cortisol secretion. Psychoneuroendocrinology 23, 353–370.
Swedish National Council on Technology Assement [Statens beredning för medicinsk utvärdering]. 2002. Gentle massage of demention [Mjuk massage vid demenssjukdom]. Available at http://www.sbu.se/sv/Publicerat/Alert/Mjuk-massage-vid-demenssjukdom/. Accessed February 27, 2010.
Takamoto, K., Sakai, S., Hori, E., Urakawa, S., Umeno, K., Ono, T., Nishijo, H., 2009. Compression on trigger points in the leg muscle increases parasympathetic nervous activity based on heart rate variability. J. Physiol. Sci. 59, 191–197.
TaskForce of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996. Heart rate variability. Standards of measurement, physiological interpretation, and clinical use. Eur. Heart J. 17, 354–381.
Thayer, J.F., Brosschot, J.F., 2005. Psychosomatics and psychopathology: looking up and down from the brain. Psychoneuroendocrinology 30, 1050–1058.
Thayer, J.F., Sternberg, E., 2006. Beyond heart rate variability: vagal regulation of allostatic systems. Ann. NY Acad. Sci. 1088, 361–372.
Uhlig, T., Kallus, K.W., 2004. Stress and stress disorders during and after intensive care. Curr. Opin. Anaesthesiol. 17, 131–135.
Uvnas-Moberg, K., 1998. Oxytocin may mediate the benefits of positive social interaction and emotions. Psychoneuroendocrinology 23, 819–835.
Vanhorebeek, I., Van den Berghe, G., 2006. The neuroendocrine response to critical illness is a dynamic process. Crit. Care Clin. 22, 1–15 v.
Vining, R.F., McGinley, R.A., Maksvytis, J.J., Ho, K.Y., 1983. Salivary cortisol: a better measure of adrenal cortical function than serum cortisol. Ann. Clin. Biochem. 20 (Pt 6), 329–335.
Wiklund, U., Koskinen, L.O., Niklasson, U., Bjerle, P., Elfversson, J., 2000. Endoscopic transthoracic sympathicotomy affects the autonomic modulation of heart rate in patients with palmar hyperhidrosis. Acta Neurochir (Wien) 142, 691–696.