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ORIGINAL ARTICLE

Effects of spa treatment on cardiac autonomic control at rest in healthy subjects

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Abstract
Purpose Heart rate variability (HRV) was analyzed after a spa-course to test the hypothesis that cardiac autonomic modulation can reflect the feeling of relaxation and well-being induced by the treatment.
Methods Twenty healthy males were administered a spa-course, consisting in classic sauna (15 min), steam bath (10 min), and soft sauna (10 min), each of them followed by a cooling-off and a rest period. Heart rate (HR) and blood pressure (BP) were measured at rest in supine position before and after the treatment. HRV was analyzed in time and frequency domains and by Poincaré plot.
Results After the treatment, systolic and diastolic BPs were decreased by about 13 and 6 mmHg, respectively ($p < 0.05$ vs. before), while HR was unchanged (55 ± 7 b/min). HRV time domain and Poincaré parameters were significantly higher after than before the spa-course: SDNN, rMSSD, SD1 and SD2 increased by 31–35 %, NN50 and pNN50 by 64 %. The ratio SD1/SD2 was 0.6 ± 0.1 in both conditions. No modification was found in normalized power of spectral component and in their ratio (LF/HF $= 1.3 \pm 1.1$, overall mean).
Conclusions The increase in HRV with no change in markers of sympatho-vagal interaction observed after the spa-course would suggest an enhanced vagal modulation of HR, possibly reflecting the relaxing effect of the treatment. HRV analysis could be a useful tool to monitor changes in individual psychophysiological condition.

Keywords Spa treatment · Sauna · Autonomic system · Heart rate variability · Stress

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Introduction

Thermal bathing is an ancient tradition in some countries as a standard health activity: sauna in Finland, steam bath in Turkey, hot water bath in Japan are very popular practices to relax and recover from both physical and mental fatigue [1–4]. These treatments are well tolerated by healthy people and have been documented to be safe also for most patients, including chronic heart failure and hypertensive subjects [5–7].

A subjective experience of relaxation and well-being is often reported after thermal bathing, whatever the characteristics [1, 3]. After 1 h of spa bathing at 40 °C, the reduced self-reported stress has been found to be associated with a decrease in salivary cortisol and chromogranin A, that are considered physiological stress markers [8]. Thermal bathing would induce a deeper and more relaxing sleep [1, 9]. These treatments have been found to induce improvement in muscle stiffness and joint mobility [6], thus relieving related symptoms such as tension headache and arthro-muscular pain [3, 9].

In recent years, the habit of thermal treatments has gained large popularity also in countries other than traditional, due to the growing number of Spa facilities even in metropolitan environment. A variety of services are offered, generally as packages of various interventions aimed to induce relaxation and relieve stress, and to improve fitness [10].

Athletes are using various methods for accelerating recovery and minimizing fatigue, including hydrotherapy and thermal treatments [10, 11]. Positive effects on performances have been described in endurance runners after some weeks of regular sauna [12] and in young soccer players after spa treatment, i.e., combined sauna, cold water immersion and jacuzzi [13]. Recovery from localized muscle fatigue has been shown to be improved by bathing methods and similarly by mist sauna [14].

The term heart rate variability (HRV) describes the beat-to-beat fluctuations of heart rate (HR) that are due to the rhythmic autonomic control of the heart [15]. Many indices can be obtained by HRV analysis, that have been shown to reflect the sympathetic and vagal activities in many physiological conditions [15, 16], including the executions of cognitive tasks [17].

More recently, it has been suggested that low values of HRV would be associated with emotions such as anxiety, sadness, anger [18, 19] as well as with high emotional arousal and maladaptive coping strategies [20]. Moreover, a negative relation has been observed between vagal HRV indices and level of stress related to work [21, 22]. On the other hand, the reduction in perceived stress due to relaxing techniques has been shown to be associated with an increase in HR autonomic modulation [23–25]. HRV parameters are nowadays used also as tools for monitoring athletes' psychophysiological condition and training status [26, 27].

We hypothesized that the effect of spa treatment on subjective feeling of well-being could be reflected in changes of cardiac autonomic modulation. HRV was therefore analyzed in a group of conditioned healthy subjects who performed a spa-course, i.e., the combination of treatments typically administered in a spa facility.

Methods

Subjects

Twenty healthy male subjects volunteered for this study (age range 21–49 years, body mass 75.5 ± 8.4 kg, height 178 ± 5.9 cm, BMI 23.7 ± 2.2). The subjects were nonsmokers and did not have a history of cardiovascular, pulmonary or neurological diseases. None of them was taking medications at the time of the study. They were all physically active, regularly exercising and training. The subjects received a description of the experimental procedure and of the methods adopted. Then, they gave their informed consent. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 2000.

Experimental procedure

The subjects were evaluated in a quiet room at comfortable temperature (26–27 °C), at least 2 h after a light meal. They were requested to abstain from caffeine and alcohol and not to exercise at high intensity in the day preceding the test. The subjects, wearing a bathrobe, lay in supine position. HR was continuously recorded by Polar RS800 (Polar Electro, Finland) for 10 min, during which the subjects were asked to remain awake, not to speak and to spontaneously breathe. At the end, blood pressure was measured by auscultatory method (sphygmomanometer Tema, Italy). The procedure was repeated before and after the subjects performed the spa treatment.

Spa treatment was carried out in a specifically equipped room (Starpool srl, Italy), where the subjects were administered a planned sequence of thermal treatments as depicted in details in Fig. 1. The series represents a so-called spa-course (Spa System—Starpool srl, Italy) and consisted in the exposure first to dry heat, classic sauna, then to moist heath, steam bath, and at the last to medium heat, soft sauna, each of them followed by a cooling-off and rest period. A shower, rapidly alternating warm and cold water, concluded the treatment. During "rest" phases, the subject lied covered on a longue chair in a quiet space and was free to drink as required. The entire treatment lasted about 75 min.

Analysis of the data

Analysis was performed off-line. Individual data were transferred to a personal computer via Polar Precision Performance Software (Polar Electro, Finland) and then analyzed by Kubios HRV software ver 2.1 (University of Eastern Finland, Kuopio, Finland). From each individual recording, two sequences of 250 successive *R–R* intervals were selected and separately analyzed. Mean *R–R* interval and mean HR were calculated, then after subtracting a linear trend, HRV analysis was carried out. The following parameters were obtained: a) time domain: SDNN (standard deviation of *R–R* intervals), rMSSD (root mean square of successive differences between *R–R* intervals), NN50 and pNN50 (number of successive *R–R* intervals differing more than 50 ms and the corresponding relative amount, respectively) together with NN50+ and pNN50+ (absolute and relative number of positive differences only); (b) frequency domain, by FFT method: low frequency (LF 0.04–0.15 Hz) power, high frequency (HF 0.15–0.40 Hz) power in normalized units (nu, i.e., as a percent of the sum of LF and HF powers); LF/HF ratio, i.e., the ratio between LF and HF power; (c) non-linear, by Poincarè plot: SD1, SD2 (standard deviation perpendicular and along the line-of-identity, respectively) and their ratio SD1/SD2. The

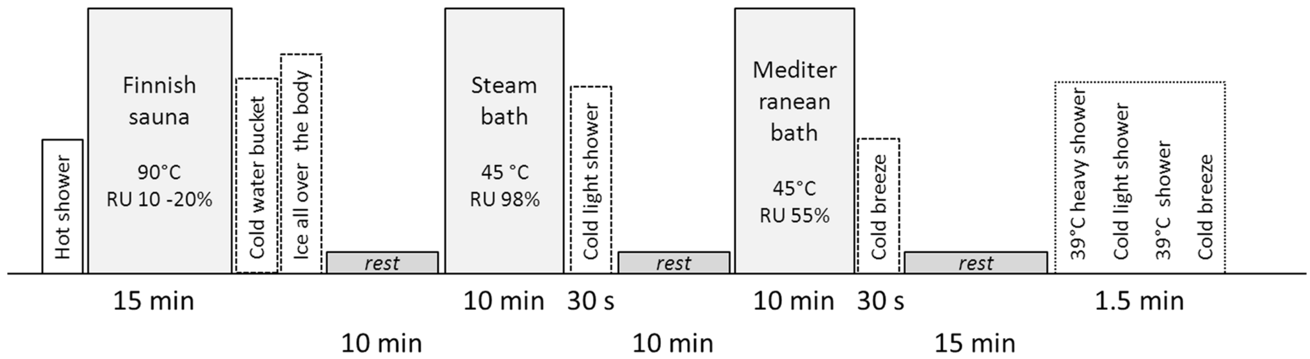

Fig. 1 Sequence of the treatments administered to the subjects during the spa-course. In the *rest* phases, the subjects lied covered on a longue chair and were free to drink as required. The four components of last treatment lasted 30, 10, 30, 20 s. *RU* relative humidity

average of the values calculated on the two sequences was used for further analysis.

Data are presented as mean and standard deviation (SD). The comparison of data before (pre) and after (post) the treatment was performed by means of parametric or non-parametric test, respectively, paired *t* test and signed rank test, according to their distribution. The level of significance was set at $p < 0.05$. Analysis was performed by means of SigmaPlot package (Systat Software Inc).

Results

Heart rate was 55 ± 8.2 b/min before the spa treatment and did not change after (54.4 ± 5.5 b/min). In contrast, blood pressure significantly decreased at the end of the course. Systolic blood pressure showed a mean decrement of 13 mmHg (from 121.4 ± 11.2 to 108.7 ± 7.3 mmHg) and diastolic blood pressure of 6 mmHg (from 74.3 ± 10 to 67.9 ± 7.7 mmHg). As a consequence mean BP, calculated as DBP + 1/3 (SBP − DBP), was reduced from the beginning by 9 %, being 90 ± 10 and 82 ± 7 mmHg before and after the treatment, respectively.

In Fig. 2, the sequences of successive *R–R* intervals are reported for a representative subject while resting supine before and after the treatment. Mean *R–R* value (continuous lines) is similar in the two conditions (0.920 and 0.995 s, corresponding to 65 and 61 b/min, before and after treatment, respectively). Amplitude of fluctuations above and below the mean value is noticeably enhanced after the treatment.

The mean values and SD of time domain and Poincarè plot parameters observed before and after the treatment are reported in Table 1, together with the values of mean *R–R* interval. All the measures were significantly higher after the treatment than before, except the *R–R* interval, as above mentioned for HR. The differences between the value after and the value before the treatment of the same parameters

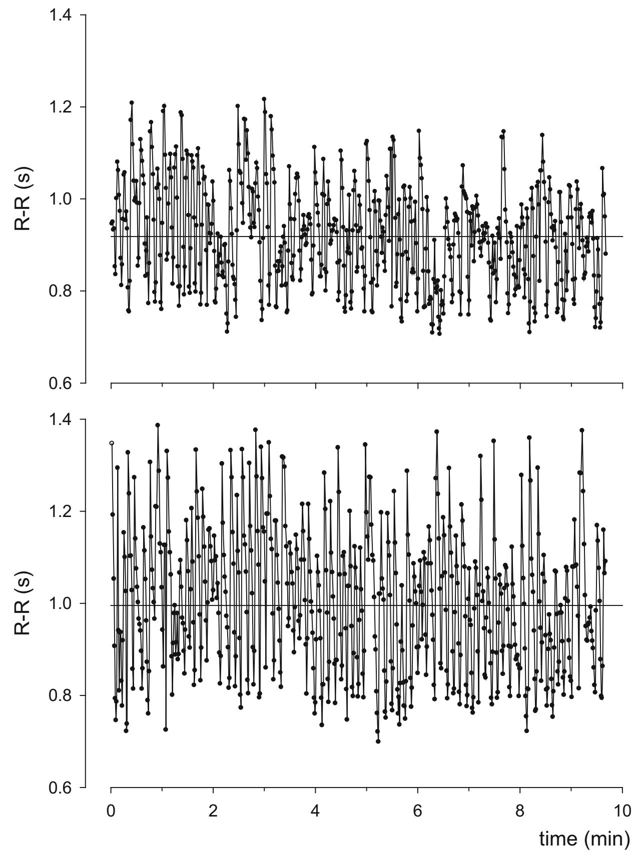

Fig. 2 Beat-to-beat HR values in a representative subject while resting supine before (*top panel*) and after (*bottom panel*) the spa-course. Note the similar mean value of HR (*dashed lines*) in the two conditions and the larger fluctuations around it after the treatment

are shown in Fig. 3. An increment by about 30 % was observed for both SDNN and rMSSD. A greater increase in NN50 and pNN50 occurred, on the average 60 and 67 %, respectively, but with large inter-individual variability. NN50+ as well pNN50+ were significantly higher after (61.4 ± 22.7 and 23.7 ± 8.1 %, respectively) than before the treatment (50.7 ± 22.5 and 20.4 ± 8.7 %, respectively), i.e., in both cases about half of total *R–R* interval

Table 1 Mean values (±SD) of time domain and Poincarè plot parameters before and after the spa-course

	Before	After
R–R (ms)	1104.3 ± 168.2	1114.4 ± 118.0
SDNN (ms)	73.0 ± 36.2	88.0 ± 34.1*
rMSSD (ms)	74.9 ± 49.7	88.9 ± 40.4*
NN50 (nr)	109.1 ± 52.3	130.0 ± 46.6*
pNN50 (%)	41.1 ± 22.0	48.7 ± 18.2*
SD1 (ms)	53.1 ± 35.3	64.0 ± 28.2*
SD2 (ms)	87.0 ± 40.4	106.6 ± 40.3*

* $p < 0.05$

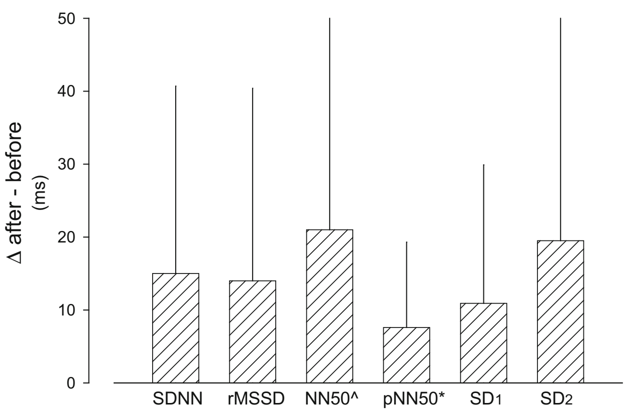

Fig. 3 Mean values (±SD) of the differences between the values before and after the treatment of time domain and Poincarè plot parameters. *SDNN* standard deviation of *R–R* intervals, *rMSSD* root mean square of successive differences between *R–R* intervals, *NN50* number of successive *R–R* intervals differing more than 50 ms, *hat symbol* unit of measurement: nr, *pNN50* percentage of NN50 with respect to total *R–R* intervals, *asterisk* unit of measurement: %, *SD1 and SD2* standard deviation, respectively, perpendicular to and along the line-of-identity of Poincaré plot

differences larger than 50 ms were positive. SD1 and SD2 increased by 37 and 34 %, respectively, while their ratio was unchanged (SD1/SD2: 0.6 ± 0.2 and 0.6 ± 0.1, before and after the treatment, respectively).

Spectral analysis of HRV showed that power of LF and HF components were, respectively, 46.3 ± 16.5 and 50.2 ± 17.9 nu, before the treatment. No change was found after the treatment, being LF 49.8 ± 15.2 nu and HF 46.5 ± 14.1 nu (overall mean, LF = 48 ± 18.8 nu, HF = 48 ± 16 nu). The LF/HF ratio was 1.35 ± 1.1, independently of the condition.

Discussion

This study showed that thermal treatments, administered as a “spa-course”, acutely affect autonomic modulation of heart rate, eliciting an increase in heart rate variability. Suggestion is made that this could be an expression of the relaxing effect induced by these procedures.

The habit of thermal treatments has gained large popularity also in countries other than traditional, i.e., Scandinavian countries, Turkey and Japan, due to the growing number of spa facilities even in metropolitan environment. Services are often offered as packages of defined interventions.

The sequence of treatments of the spa-course adopted in this study does resemble the usual ritual of Finnish sauna, that traditionally consists in 2–3 stays of 5–20 min in the sauna, interspersed with cooling-off periods and recovery at room temperature with intake of fluids [2, 5]. In our protocol, three periods of exposure to high temperature, namely sauna, steam bath and Mediterranean bath, were administered, each of them followed by a cooling maneuver and a rest phase. At the end of this spa-course, no subject reported any problem or discomfort. Thermal treatments indeed have been shown to be well tolerated by healthy adults as well as by patients, for instance subjects with cardiovascular pathologies [2, 3, 5–7].

After the end of the treatment, both systolic and diastolic blood pressures were slightly but significantly lower than before, while HR was unchanged. These findings suggested that recovery was not fully completed after about 20 min elapsed from the last heat–cold exposure.

Normalization of body temperature and cessation of sweating after the usual hot–cold cycles of sauna have been reported to occur after about half an hour [2]. A similar time has been shown to be sufficient for HR and BPs to, respectively, decrease and increase back to control values after mist but not after dry sauna [28]. The magnitude of the responses to heat exposure, and thus their recovery, depends indeed on the characteristics of treatment, namely temperature, relative humidity and length of exposure [3, 6, 28–30]. Nonetheless, the type of cooling-off has been shown to play the crucial role in reversing the cardiovascular changes due to heat [2, 3, 6].

None of the cool-off phases of the spa-course evaluated in this study can be reasonably considered a strong maneuver, definitely not the last one, i.e., cold breeze. As a consequence, the vasodilation due to heat exposure could have been only partially reversed, thus justifying the persisting low BPs we observed after the end of the treatment. On the other hand, the final short sequence of alternate warm and cold showers could have quickened the recovery of HR via vagal activation due to facial receptors stimulation [31]. As we did not collect data during the treatment, however, no definite conclusion can be drawn on the dynamics of cardiovascular parameters immediately after the spa-course.

The interesting finding of this study was that the similar HR found before and after the spa-course was associated with different values of HRV. Indices of both rapid (rMSSD, NN50, pNN50 and SD1) and slow (SDNN and SD2) HR oscillations were significantly higher after than before the course. Fast fluctuations, due to respiratory activity, are mediated by vagal nerves only, whereas both vagal and sympathetic branches have a role in mediating fluctuations below 0.15 Hz, related to arterial pressure control [15]. Thus, the treatment would have brought about an enhancement in autonomic modulation of HR in the entire range of frequencies.

Normalized powers of HF and LF spectral components were similar before and after the treatment, suggesting no change in the relative role of the two main rhythms in influencing beat-to-beat HR. The LF/HF ratio is considered an estimate of sympatho-vagal interaction [15, 16]. The same is true for SD1/SD2 ratio, reversing the terms. Both ratios remained stable after the treatment, namely the spa-course seemed not to have elicited a change in autonomic balance.

Nonetheless, considering the above-mentioned role of vagal nerves in transmitting all fluctuations, suggestion can be made that the overall increased HRV after the spa-course could be the expression of the shift toward the vagal dominance induced by the treatment.

A subjective feeling of well-being and tranquility have been often reported to be associated with thermal treatments [1, 3], likely due to the increased beta-endorphin levels [32]. A limit of our study is that we did not administer any questionnaire to investigate the subjective sensations after the spa-course. Nonetheless, the lack of any complaints and warnings of unpleasant effects suggested that the treatment resulted well accepted, if not enjoyable, by each participant.

Observations are reported that autonomic modulation of HR could be affected by the individual psychological condition. Emotions such as anxiety, sadness, anger [20, 21], as well as work-related stress [18, 19] have been reported to be characterized by low values of HRV. Thermal treatments have been demonstrated to induce a decrease in stress markers, such as salivary cortisol and chromogranin A [8]. Hypothesis can be made, therefore, that the augmented modulation of HR after the spa-course could be an expression of the relaxing effect of the treatment. Short sessions of yoga and meditation practice have been observed to induce a reduction in perceived stress and concurrently an increase in HRV [23, 24]. Moreover, in a longitudinal study on healthy young students, changes in depressive mood have been found to be associated with opposite modifications in vagal markers of HRV [22].

In conclusion, this study showed that thermal treatments administered as a spa-course acutely affected the cardiac autonomic system, eliciting an enhancement in vagal modulation of HR. Suggestion was made that this response could be the reflection of the positive influence of the treatment on subjective sensation of well-being. Even if preliminary, these findings seem to add evidence to the use of HRV for monitoring the individual psychophysiological condition.

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Conflict of interest The authors declare no conflict of interest.

Human and Animal Rights All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

Informed consent Informed consent was obtained from all subjects for being included in the study.

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