RETRACTED: EFFECT OF RADIOFREQUENCY ON SYMPATHETIC NERVOUS SYSTEM FUNCTIONING

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ABSTRACT

Radiofrequency devices for aesthetic applications such as body and face skin tightening, cellulite reduction, rhytids and body contouring treatments are becoming increasingly popular in clinics worldwide due to their demonstrated efficacy and safety combined with a relative lack of complications and down-time. Heating of body tissues by radiofrequency (RF) energy is a mechanism for therapeutic. Such effects may be produced by local changes in tissue temperature (for example, thermally induced changes in regional blood flow) and others may be systemic effects due to the additional thermal load on the body. An elevated core temperature increases metabolism and certain other functions such as heart rate, respiration rate, and nerve conduction velocity.

The aim of this study was to determine whether healthy subjects, non-obese, undergoing treatment with radiofrequency could see changes in REE and SNA, GSR.

Twenty healthy adult female, took part in the study. The study protocol consisted of the treatment of twenty minutes of radiofrequency in the abdominal region. Participants in the study were presented in the morning at 8 am fasting for at least 12 h, underwent measurement of REE, HRV and GSR 60 minutes prior to treatment, immediately after treatment, and 120 minutes after treatment.

Radiofrequency induced significant increases of REE, sympathetic activity, and GSR. This result is also useful in the interpretation of the relationship between the sympathetic nervous system and food intake in young subjects. It has demonstrated a significant influence of sympathetic activity on eating behavior, also through an increase in thermogenesis.

Keywords: radiofrequency devices, sympathetic nervous system, thermogenesis, resting energy expenditure, eating behavior.

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Introduction

As the aging population in our society continues to increase, many people are seeking technologies and treatments to help achieve a more youthful appearance. This, coupled with the general population’s busy lifestyle, is leading towards a desire for procedures with minimal side effects and little to no recovery time.

Cutaneous aging is a net process resulting from intrinsic and extrinsic factors and is associated with many pathologic changes, including net reduction in dermal components, tissue degeneration, and reduced skin elasticity, all of which ultimately lead to macroscopic sagging and wrinkling. During the last decade, a number of injectable dermal fillers and laser modalities have been developed to counter the aging process.
Of the skin rejuvenation modalities, radiofrequency (RF) has emerged as a safe and effective treatment for a broad range of aesthetic and medical indications. The RF devices for aesthetic applications such as body and face skin tightening, cellulite reduction, rhytids and body contouring treatments are becoming increasingly popular in clinics worldwide due to their demonstrated efficacy and safety combined with a relative lack of complications and downtime.

The mechanism of action of RF in a medical application is based on an oscillating electrical current forcing collisions between charged molecules and ions, which are then transformed into heat. The RF generated tissue heating has different biologic and clinical effects, depending on the depth of tissue targeted, the frequency used, and specific cooling of the dermis and epidermis. The depth of penetration of RF energy is inversely proportional to the frequency. Consequently, lower frequencies of RF are able to penetrate more deeply. RF technology also has the ability to noninvasively and selectively heat large volumes of subcutaneous adipose tissue. By selecting the appropriate electric field, one can obtain greater heating of fat or water. In cosmetic dermatology, RF is most commonly used to noninvasively tighten lax skin; to contour the body by influencing adipocytes; and, consequently, to improve the appearance of cellulite.

Radiofrequency emits focused electromagnetic waves which meet resistance within the tissue, generating heat. This thermal energy affects collagen’s triple helix structure, subsequently breaking the intramolecular hydrogen bonds resulting in immediate collagen contracture and subsequent neocollagenesis within the dermis without disrupting the epidermis. Excessive exposure to RF energy can produce burns or other thermal damage to tissue, or, for whole body exposure, physiological stress resulting from excessive body heating. Since the 1960s, exposure guidelines for human exposure to RF energy in effect in the United States and elsewhere have been based in large part on animal studies. In particular, the limits in whole-body exposure are based on responses of animals subjected to whole-body exposures at levels that are sufficient to produce behavioral changes but not thermal damage to tissue. Because of the large interspecies differences in thermoregulation, the observed responses in the animals used for these studies (chiefly, rodents and primates) may not be representative of human responses under similar exposure conditions.

Until recently there has been almost a complete lack of data from humans exposed for extended times to RF energy under conditions that are relevant to setting exposure guidelines. Several recent studies at the John B. Pierce Laboratory in New Haven CT and the Air Force Research Laboratory (AFRL) at Brooks AFB, Texas by Adair and colleagues have measured thermoregulatory responses to extended (45 minute) RF exposures of human volunteers under controlled environmental conditions. These studies measured a variety of sensory and thermophysiological endpoints in subjects exposed to RF energy at frequencies of 100, 450, and 2450 MHz. This sophisticated method of transepidermal, noninvasive RF thermal delivery provides a variable and controversial tightening effect, which is not usually apparent, if at all, until dermal remodeling occurs a few months after the treatment. Noninvasive tissue tightening treatments have an inherent safety limitation because energy is delivered through the skin surface and the threshold epidermal burn temperature is significantly lower than the optimal temperature for the collagen contraction.

These studies are the first, and apparently only, measurements of physiological responses of humans exposed for extended periods to RF energy of substantial parts of their bodies. The tests were conducted under carefully controlled environmental conditions and at exposure levels well above present U.S. and international limits.

An elevated core temperature increases metabolism and certain other functions such as heart rate, respiration rate, and nerve conduction velocity. The largest component of daily energy expenditure, especially in people with sedentary lifestyle, is resting energy expenditure (REE). Resting energy expenditure (REE) accounts for 60-75% of total daily energy expenditure and decreases with age and physical inactivity. It is well known that fat-free mass (FFM) accounts for the majority of inter-individual variability in REE. The sympathetic nervous system (SNS) is an important control mechanisms of the body. The SNS shows physiologic fluctuations with age which is considered to be related often to differences in the REE.

Activation of the SNS is measurable by various parameters, as galvanic skin responses (GRS), and heart rate variability (HRV).

HRV power spectral analysis is a well-accepted, useful, and non-invasive method, and has provided a comprehensive quantitative and qualitative evaluation of neuro-autonomic function under various
research and clinical settings[10,11,12]. In general, power spectral analysis of HRV has shown at least two distinct regions of periodicity in electrocardiogram R-R intervals[13,14]. Previous investigations demonstrated that the percentage of body fat[15], energy storage[16], and glucose-induced thermogenesis[17] are correlated with differences in the power spectral components.

A series of recent studies with the HRV power spectral analysis have shown that obese young women possess significantly lower sympathetic activity against various thermogenic perturbations, such as cold exposure[18], capsaicin-containing yellow curry diet[19], and mixed food intake[20]. Unlike invasive measurements such as plasma catecholamine concentration, catecholamine turnover, and muscle sympathetic nerve activity, the HRV power spectral analysis lightens the burden imposed on subjects during an experiment and is a suitable and valuable approach to evaluating vegetative activity in large-scale of obesity research. Although the relation between HRV and body mass index has been shown, as reported in the studies cited above, other authors have indicated that no correlation was noted between HRV and body mass index[11,21]. On the other hand, Hirsch and Mackintosh have reported their perplexity about the controversial influences of autonomic nervous activity (measured by HRV) on body weight[22]. GSR is a change in electrical conductivity between two points on the respondent’s skin. Fahrenberg and Wientjes[23] report GSR to be the most convenient physiological indicator for workload and GSR amplitudes may reflect the amount of affective or emotional arousal elicited by a stimulus or a situation. GSR is among the most suitable measures of arousal in studies regarding the autonomic nervous system.

The aim of this study was to determine whether healthy subjects, non-obese, undergoing treatment with radiofrequency could see changes in REE and SNA, GSR.

**Methods**

**Subjects**

Twenty healthy adult female, took part in the study. All participants were in good health, as defined by the absence of cardiovascular disease, and no history of endocrine disorders and were not taking any medication. Prior to data collection, the purpose of this study was explained thoroughly and informed consent was obtained from each participant, according to the Declaration of Helsinki.

**Study protocol**

The study protocol consisted of the treatment of twenty minutes of radiofrequency (“Rinnova plus frax” Its group srl) in the abdominal region. Participants in the study were presented in the morning at 8 am fasting for at least 12 h, underwent measurement of REE, HRV and GSR 60 minutes prior to treatment, immediately after treatment, and 120 minutes after treatment.

**Measurement of HRV responses, GSR and REE**

The HRV-power spectrum was evaluated on a 5-min long ECG recording. The ECG signal was acquired on a PC at 100s/s with an electrocardiograph (Cardioline, delta-I plus, Italy) connected to the serial port of a PC; a custom software written with LabView (National Instruments, Texas) was used for data acquisition and analysis. All the R-waves were automatically recognized and all the R-R intervals were calculated. The R-R-intervals sequence was re-sampled to obtain a constant-time based signal (10 samples/sec). The Fast Fourier Transform was then applied to this signal and visualized in the form of power spectrum. The absolute values of this spectrum were, finally, summed in the low frequency (0.04-0.15 Hz; LF), and high frequency (0.15-0.40; HF) range. LF, HF were the values used to estimate the sympathetic and parasympathetic activity[18].

The GSR parameters were measured simultaneously using the SenseWear Pro Armband[24] (version 3.0, BodyMedia, Inc. PA, USA), which was worn on the right arm over the triceps muscle at the midpoint between the acromion and olecranon processes, as recommended by the manufacturer.

REE was measured by breath-by-breath respiratory gas exchange with the indirect calorimetric device (VMax 29, Sensor Medics, USA), using a mask. Gas analyzers were calibrated before each measurement using three known standard gas concentrations. Measurements were ceased once a 5-min steady-state period was achieved or after 30 min, whichever occurred first. The indirect calorimeter was connected to an IBM-compatible personal computer for the management and storage of data.

**Statistical analysis**

The statistical program GraphPad Prism for Windows (v.5.01) (San Diego, CA, USA) was used for the analysis and treatment of the data. Physiological responses during the experimental ses-
sion were evacuate using one-way analysis of variance (ANOVA) with repeated measurements, as well as the Student’s t-test, when appropriate. When a significant F value emerged (p<0.05), the Bonferroni multiple comparisons test was performed to compare each group with the other ones. Data are reported as mean (M) ± standard deviation (SD).

Results

Physical characteristics

The physical characteristics of the subjects participating in the study are presented in Table 1.

<table>
<thead>
<tr>
<th>Nº</th>
<th>Age (Years)</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (Kg)</td>
<td>57.7 ± 4.3</td>
<td></td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.62 ± 2.2</td>
<td></td>
</tr>
<tr>
<td>BMI (Kg/m2)</td>
<td>21.9 ± 1.9</td>
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</tbody>
</table>

Table 1: Physical characteristics of the subjects.

Responses to stress treatment

Radiofrequency induced significant increases of REE, sympathetic activity, and GSR. The analysis of variance showed significant differences between the experimental conditions for REE (F(2,57) = 2.87, p < 0.05), GSR (F(2,57) = 2.45 p < 0.05), LF (F(2,57) = 3.12, p < 0.01).

Figure 1 reports the change in REE. This variable reached a peak immediately after treatment and it remained significantly elevated at 120 min after treatment, compared to basal values.

Figure 2 shows the variations of GSR. This variable reached a peak immediately after treatment and it remained significantly elevated at 90 min treatment, compared to basal value.

Figure 3 shows the change in LF. This variable reached a peak immediately after treatment and it remained significantly elevated at 120 min after treatment, compared to basal values. No ventricular arrhythmias or ST segment abnormalities were recorded.

Figure 4 shows the change in HF. HF values not show changes. The analysis of variance shows no significant effect.
Discussion

The demand for noninvasive methods of facial and body rejuvenation has experienced exponential growth over the last decade. There is a particular interest in safe and effective ways to decrease skin laxity and smooth irregular body contours and texture without downtime. These noninvasive treatments are being sought after because less time for recovery means less time lost from work and social endeavors. The RF treatments are traditionally titrated to be nonablative and are optimal for those wishing to avoid recovery time. Not only is there minimal recovery but there is also a high level of safety with aesthetic RF treatments. The RF devices, offer a nonablative and noninvasive treatment option. By delivering RF energy in the form of a monopolar electric current, heat is generated because of tissue resistance to flow. Heat damage, and the subsequent inflammatory cascade, alters collagen and produces a tightening effect(27).

Initially, in 2002, the Food and Drug Administration granted clearance for an RF device to treat periorbital rhytids. Later, the device was cleared for facial laxity and, in 2006, the device was cleared for treatment of nonfacial skin, including the abdomen, thigh, and buttocks. Although a number of studies exist that demonstrate RF effect on facial skin, relatively fewer clinical studies have evaluated RF on nonfacial skin. To our knowledge, this is the first study to examine the effect of short-term of RF on HRV, GSR and REE.

This study sheds further light on the controversial issue regarding the relationship between autonomic nervous system and body weight. The present experiment indicates a increase of vegetative during a treatment of RF and the increase of autonomic control regarding the sympathetic component. The increase of the sympathetic branch could be an important factor in the reduce the obesity. Indeed, a increase of sympathetic activity is related to a high energy expenditure, so that a increased energetic cost could explain a decrease the body weight. The sympathetic nervous system is involved in the control of body weight(28), partly through its effect on energy expenditure(29). The present experiment confirms also that GSR is a sensitive psycho-physiological index of stress. Since the modification of GSR is related to changes in sympathetic arousal(30). The evidences reported in this paper corroborate the validity of GRS as non-invasive tool in research on responses to stress(31). The age-related decline in the vegetative control has been considered an important factor in the reduction of resting energy expenditure, therefore, young healthy male were analyzed. Indeed, suppression of sex hormones to post-menopausal levels reduces resting energy expenditure in young healthy women, through a reduction of autonomic nervous activity(26-35). The originality of the present experiment is to emphasis the difference in the sympathetic modulation immediately after treatment with RF and it remained significantly elevated at 120 min after treatment, compared to basal values.

This result is also useful in the interpretation of the relationship between the sympathetic nervous system and food intake in young subjects. It has demonstrated a significant influence of sympathetic activity on eating behavior(36), also through an increase in thermogenesis(37-39). Many experimental evidence has demonstrated that an increase in sympathetic and thermogenic activity reduces food intake. Therefore, the obesity can be due to an increase in food intake associated to a reduced activity of the sympathetic nervous system and thermogenesis(40-50).

Although food intake was not measured, the results of the present experiment are consistent with the hypothesis that a reduction in autonomic activity could play a determinant role in the increase in food intake and in the induction or maintenance of obesity.

References

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Effect of radiofrequency on sympathetic nervous system functioning


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