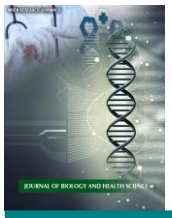

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Research Article

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A New Model for Managing Overweight: The Synergy between Nutraceuticals and Biofeedback to Regulate Aberrant Autonomic States and Counteract Emotional Hunger

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Abstract

Obesity and overweight represent global challenges involving psychophysiological factors such as stress and emotional hunger. This article proposes an innovative approach that integrates biofeedback (using eVu TPS technology) and Siegel's window model to regulate the autonomic state of the nervous system. Personalized natural supplements are suggested for each aberrant autonomic state (hyperactivation or hypoactivation) to promote psychophysical balance. This multidimensional approach offers an innovative intervention to reduce emotional hunger and promote overall well-being. By combining advanced technology and nutritional science, this integrated approach aims to address the root causes of overweight, reduce chronic stress and encourage mindful eating choices. Moreover, it bridges neuroscience, nutrition and behavioral psychology, overcoming the fragmentation between disciplines and offering a holistic and innovative solution.

Keywords: Obesity; Nutraceuticals; Emotion; Hunger; Overweight; Energy; Metabolism; Autonomic Nervous system; Eating behaviour

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Introduction

Metabolism is influenced by stress through the nervous and hormonal systems, which regulate hunger, satiety and energy. Acute stress situations can suppress appetite, while chronic stress activates the HPA axis, increasing cortisol and leading to harmful metabolic changes. This fosters visceral obesity, insulin resistance and issues such as diabetes, dyslipidemia and hypertension. Chronic stress induces inflammation, negatively affecting tissues and organs, including the heart and muscles thereby increasing cardiovascular risk. In obesity, altered levels of hormones and cytokines further aggravate metabolism. Additionally, unhealthy lifestyle habits linked to stress, such as an unbalanced diet and sedentary behavior, contribute to a vicious cycle of weight gain and metabolic disorders. Targeted therapies to mitigate stress effects on obesity and metabolism are currently under development [1].

Obesity is a complex phenomenon influenced by multiple factors, including eating habits, chronic stress and Autonomic Nervous System (ANS) dysregulation [2]. Recent studies show that both acute and chronic stress can alter eating behavior, leading to the consumption of high calorie foods as a response to negative emotions [3].

Biofeedback, through modern technologies such as eVu TPS, allows for monitoring and regulating physiological parameters, improving awareness and emotional control [4]. Compared to other biofeedback devices like HeartMath or emWave, eVu TPS stands out for its ability to monitor a broader range of real-time data, including Heart Rate Variability (HRV), skin conductance and skin temperature key parameters for understanding stress responses [5].

Additionally, eVu TPS utilizes an intuitive interface that facilitates implementation without extensive training,

making it ideal for both clinicians and nutritional coaching [6]. However, compared to HeartMath, eVu TPS could benefit from greater emphasis on patient education tools, such as interactive mobile apps promoting long-term self-monitoring.

Thanks to its user-friendly interface, this tool enables immediate monitoring of physiological parameters and is easily integrable into clinical and nutritional coaching protocols, as well as with tools for body composition analysis, such as Bioelectrical Impedance Analysis (BIA), without requiring advanced expertise. Its accuracy makes it particularly suitable for personalized applications in managing stress and emotional hunger, essential aspects in combating obesity and overweight. Compared to other devices, it offers unique versatility, allowing interventions to be tailored to individual needs in real time while reducing consultation times and costs [7].

Another contribution to managing overweight comes from nutraceuticals, which use natural active ingredients to support physiological processes [8]. Siegel's window of tolerance model provides a practical framework for classifying autonomic states into hyperactivation, hypoactivation and optimal activation, enabling the personalization of relaxation techniques and the use of supplements [9].

In this context, two complementary approaches are integrated: Nutraceutical interventions and stress management, using Siegel's window of tolerance model as a reference. This model offers a practical framework for understanding and regulating autonomic states, enabling the effective personalization of nutritional strategies and relaxation techniques.

Biofeedback Technologies and eVu TPS

The eVu TPS is a wearable system that enables the monitoring of key physiological parameters, which can be utilized for stress management and eating behavior regulation:

Heart Rate Variability (HRV): HRV measures the heart's ability to adapt to various situations, reflecting the health of the autonomic nervous system. High HRV is associated with a good balance between the sympathetic and parasympathetic systems, promoting stress resilience. Conversely, low HRV correlates with a state of sympathetic dominance, which can lead to chronic stress and overeating as an emotional response, increasing the risk of obesity. Reduced HRV is also linked to sleep disturbances, irritability and a higher risk of cardiovascular and metabolic dysfunctions [4].

Skin conductance: This parameter measures variations in sweating, directly correlated with emotional arousal and stress levels. Increased skin conductance indicates an intense physiological response to stressful situations, potentially associated with emotional eating and impulsive food choices. In states of chronic hyperactivation, this amplified response often drives comfort-seeking through food [5].

Skin temperature: This parameter detects changes in surface temperature, indicative of relaxation or stress states. During hyperactivation, skin temperature may decrease, signaling heightened anxiety or a fight or flight response. This can encourage emotional overeating, with a preference for sugar-rich foods to alleviate discomfort. In hypoactivation conditions, skin temperature may increase, indicating reduced metabolic activity and a tendency toward chronic fatigue, often associated with compensatory food choices [6].

Respiration (by inference): Monitoring respiratory rhythm provides crucial insights into emotional and relaxation states. Rapid, shallow breathing indicates acute stress or anxiety, associated with increased cortisol production that stimulates emotional hunger and the consumption of high-calorie foods. Conversely, deep and slow breathing helps reduce stress and can be used to manage emotional hunger. Altered respiratory rhythms, such as those typical of insomnia, further increase the propensity for overeating [10].

The eVu TPS supports the transition to autonomic balance through real-time visual and auditory feedback tailored to the user's physiological responses.

Application of Siegel's Window

The regulation of the Autonomic Nervous System (ANS) is influenced by a combination of genetic factors, life experiences, stress and trauma. According to Stephen Porges' Polyvagal Theory, the evolution of the ANS endowed humans with specialized neural circuits to adaptively respond to environmental stimuli, regulating both behavioral and physiological responses. This ability to modulate the ANS explains individual variability in autonomic regulation and how humans adapt to contexts of safety or threat [2,3,7,11,12].

Autonomic nervous system states and emotional hunger

Daniel Siegel's window of tolerance (2012) integrates these concepts by describing the functional states of the ANS into three main categories: Hyperactivation, hypoactivation and optimal activation [9].

Hyperactivation: Dominated by the sympathetic system, hyperactivation is characterized by anxiety and hypervigilance. It leads to comfort eating and the consumption of sugar- and carbohydrate-rich foods, which stimulate serotonin release, offering temporary relief from stress [7]. Hyperactivation disrupts stress hormone

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regulation, compromising appetite control and causing episodes of emotional hunger and hyperphagia [11]. Additionally, excess cortisol can reduce insulin sensitivity, predisposing individuals to fat accumulation and metabolic imbalances [3]. Sleep disturbances, common in this state, exacerbate weight gain by impairing metabolism and amplifying ghrelin production [7].

Hypoactivation: A shutdown state dominated by the dorsal parasympathetic system, hypoactivation is characterized by apathy and isolation. In this state, comfort food often caloric and carbohydraterich becomes a means of alleviating fatigue and compensating for low emotional energy [11]. Hypoactivation significantly slows metabolism, reducing energy expenditure and promoting fat accumulation, particularly in the abdominal region [2]. This condition is often accompanied by a lack of energy and motivation, leading to the consumption of high-calorie foods, such as sugars and fats, for temporary relief from emotional and physiological apathy [7]. Hormonal imbalances play a crucial role, with increased ghrelin stimulating appetite and decreased leptin signaling satiety, resulting in a tendency to overeat [3]. Fluid retention is also common due to reduced intestinal motility and lymphatic system activity, impairing fluid drainage [11]. The typical lack of physical activity in this state further contributes to weight gain, as the body is less inclined to burn calories, aggravating the positive energy balance.

Optimal activation: This state represents a balance between the sympathetic and ventral parasympathetic systems. It supports mindful food choices and the ability to distinguish between physical and emotional hunger, preventing the use of food as an emotional regulator [3].

Personalized Nutritional Recommendations

For each autonomic state, targeted supplements are suggested, supported by scientific evidence and tailored to physiological needs.

Hyperactivation of the nervous system

Liver detox (dandelion, milk thistle, etc.)

Role: Supports liver function and the metabolism of stress hormones, such as cortisol. Improved liver functionality reduces toxic load and inflammation, enhancing autonomic relaxation and reducing muscle tension [13].

Emotional hunger: By improving the body's ability to manage stress, it helps reduce episodes of emotional eating and comfort food consumption.

Magnesium

Role: Essential for the regulation of the autonomic nervous system. It reduces anxiety and sympathetic hyperactivation, promoting muscle relaxation and improving sleep [14].

Emotional hunger: Reduces emotional eating episodes by lowering stress and the urge to consume sugar and carbohydrate-rich foods.

Omega-3

Role: EPA and DHA fatty acids modulate systemic inflammation and improve neuronal plasticity, supporting emotional balance and reducing stress responses [15].

Emotional hunger: Stabilizes mood, reducing the need to use food as a self-regulation mechanism.

Griffonia simplicifolia

Role: A natural source of 5-HTP, a serotonin precursor that regulates mood and reduces hyperactivation of the autonomic nervous system [16].

Emotional hunger: Regulates appetite and reduces compulsive eating impulses associated with anxiety and negative emotions.

Hypoactivation of the nervous system

Carnitine

Role: Stimulates cellular energy production in mitochondria, improving metabolism and countering apathy and chronic fatigue typical of hypoactivated states [17].

Emotional hunger: Reduces the tendency to seek high-calorie foods to compensate for a lack of energy, promoting more balanced energy regulation.

Ginseng with Griffonia

Role: Ginseng acts as an adaptogen, enhancing vitality and cognitive function, while Griffonia regulates mood, aiding recovery from states of low motivation and apathy [18].

Emotional hunger: Together, they reduce the attraction to comfort foods linked to low energy and depressed mood, encouraging more mindful food choices.

Fucus

Role: A seaweed rich in iodine that stimulates thyroid function and basal metabolism, improving energy levels and counteracting the metabolic sluggishness of hypoactive states [19].

Emotional hunger: Supports a more efficient metabolism, reducing the need to consume carbohydrates to compensate for chronic fatigue.

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Free radicals, autonomic dysregulation and emotional hunger

Emotional hunger, often accompanied by an uncontrollable craving for sugars, is a common response to chronic stress. Stress induces the secretion of glucocorticoids such as cortisol, which stimulate the production of Reactive Oxygen Species (ROS) and increase oxidative stress [2]. Oxidative stress, driven by an excess of free radicals, disrupts the functions of key neurotransmitters, including serotonin and dopamine, negatively impacting appetite regulation mechanisms and promoting cravings for high-calorie foods [3]. This vicious cycle between free radicals and emotional hunger can lead to overeating and fat accumulation, exacerbating emotional distress [7].

Free radicals also damage nerve cells involved in emotional regulation, worsening stress perception and increasing reliance on comfort food. The craving for sugars is a biological response to the need for serotonin, often impaired by ROS and systemic inflammation [4]. Thus, an excess of free radicals has a significant impact on the Autonomic Nervous System (ANS), which regulates vital functions such as heart rate, blood pressure and digestion. Oxidative stress damages nerve cells, disrupting the balance between the sympathetic and parasympathetic components of the ANS. This imbalance can result in a dominance of sympathetic activity, often associated with fight or flight responses, reducing the efficiency of the parasympathetic component linked to "rest and digest" functions [2].

The accumulation of Reactive Oxygen Species (ROS) also impairs the functionality of neurotransmitters such as serotonin and acetylcholine, which are crucial for balanced autonomic regulation **(Figure 1)** [4]. This can manifest as symptoms such as tachycardia, hypertension and gastrointestinal alterations, further contributing to a decline in overall well-being. A diet rich in antioxidants, combined with stress management techniques, is crucial to breaking the cycle of emotional hunger.

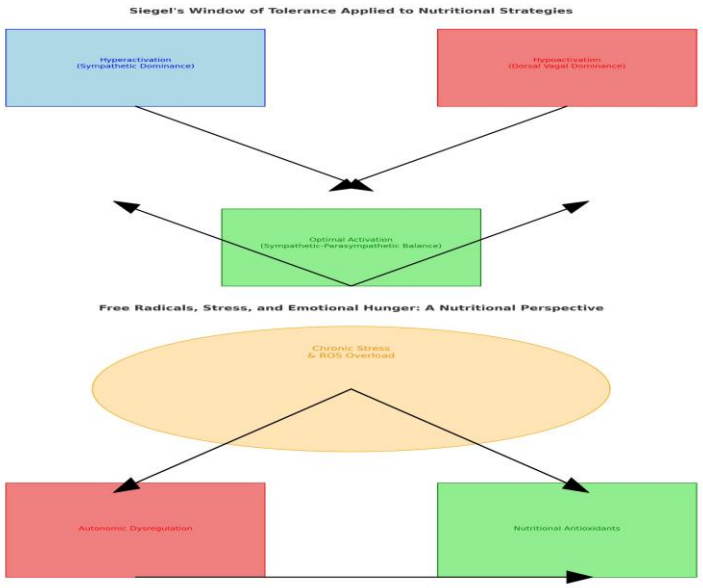

Figure 1: Free radicals, stress and emotional hunger: A nutritional perspective.

Biofeedback Interventions for Aberrant Autonomic States

Hyperactivation state characteristics

High stress, emotional hunger, muscle tension and sleep difficulties.

Biofeedback techniques with eVu TPS:

Heart Rate Variability (HRV) monitoring: HRV biofeedback reduces sympathetic nervous system activity and improves autonomic regulation of heart rhythm. In hyperactivation states, the primary goal is to increase HRV, encouraging parasympathetic activation to reduce anxiety and muscle tension [4].

Guided diaphragmatic breathing: Stimulating deep and slow breathing helps modulate the vagus nerve, activating the parasympathetic system and reducing stress. This technique enhances relaxation and contributes to stabilizing the autonomic response [10].

Galvanic Skin Response (GSR) monitoring: Measuring skin conductance evaluates emotional arousal and stress levels. Using GSR guides users toward reducing

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sympathetic tone, promoting a state of calm and enhancing emotional resilience [5].

Hypoactivation state characteristics

Lack of energy, slow metabolism, apathy and reduced motivation.

Biofeedback techniques with eVu TPS:

Real-time visual feedback to enhance parasympathetic tone: Providing real-time visual feedback helps stimulate and strengthen parasympathetic tone, alleviating fatigue and promoting energy recovery [12].

HRV monitoring to activate the parasympathetic system: In hypoactive states, HRV monitoring identifies and enhances good vagal tone. This is crucial for stimulating recovery, improving metabolism and reducing symptoms such as fatigue and apathy [2].

Skin conductance regulation: Biofeedback on skin conductance helps users monitor and manage their level of emotional activation, fostering a more balanced and adaptive response [6].

Stress resilience training: The eVu TPS can train patients to transition quickly from a hypoactive state to an optimal activation state, improving physiological control and autonomic balance [11].

Optimal activation state characteristics

Psychophysical balance, regular hunger, emotional stability.

Biofeedback techniques: Maintaining HRV: through mindfulness exercises and progressive relaxation, it is possible to sustain the balance between the sympathetic and parasympathetic systems, preventing shifts toward hyperactivation or hypoactivation states [12].

Discussion

The role of the autonomic nervous system in metabolism and emotional hunger: Metabolism and emotional hunger are closely influenced by the Autonomic Nervous System (ANS), which mediates bodily responses to internal and external stimuli [1]. Biofeedback directly impacts the ANS, improving emotional and physiological regulation, while Bioelectrical Impedance Analysis (BIA) provides a precise view of body composition, essential for personalizing nutritional interventions and balancing metabolism.

The impact of chronic stress on eating behavior and visceral fat accumulation: Chronic stress alters energy metabolism, promoting the consumption of high-calorie foods and the accumulation of visceral fat [7]. Using BIA technology, nutritionists monitor changes in body composition, while biofeedback reduces sympathetic activation, addressing stress at its root and limiting comfort eating [4].

Modulating the autonomic nervous system with biofeedback: An innovative approach Biofeedback is an advanced technology that guides patients toward conscious regulation of emotional and physiological states [11]. Its integration with BIA analysis enables a synergistic intervention: biofeedback modulates autonomic states, while BIA provides an objective measurement of metabolic and compositional improvements related to autonomic regulation.

Advanced technologies like evu tps for emotional and behavioral regulation: Devices such as eVu TPS allow targeted interventions on emotional hunger, helping patients develop awareness of their emotional and physiological states [7]. BIA technology complements the intervention by tracking metabolic and body composition progress, supporting the adaptation of nutritional plans [1].

Biofeedback and emotional hunger: A multidimensional intervention for integrated health Combining biofeedback and BIA provides an integrated approach. Biofeedback addresses the emotional component, while BIA offers quantitative data to adapt nutritional strategies. This approach ensures precision and personalization in the intervention, improving overall outcomes.

The Role of nutraceuticals in regulating metabolism and emotional hunger: Nutraceuticals support metabolic regulation and emotional hunger control through natural active ingredients. Supplements such as Griffonia, Fucus and Omega-3 modulate neuroendocrine axes and eating behaviors, contributing to mood stabilization and metabolism optimization [7]. In synergy with biofeedback and BIA, nutraceuticals further personalize the intervention [15].

Conclusions

The combined use of biofeedback, eVu TPS technology and targeted nutraceuticals offers an innovative, integrated strategy for managing overweight and emotional hunger, surpassing traditional approaches that focus on isolated aspects like diet, stress management or behavior **(Figure 2)**. Personalizing interventions based on Siegel's window model enables action on both physical and emotional-behavioral components. Autonomic regulation through biofeedback is supported by evidence demonstrating improvements in HRV, reductions in cortisol levels and increased emotional awareness.

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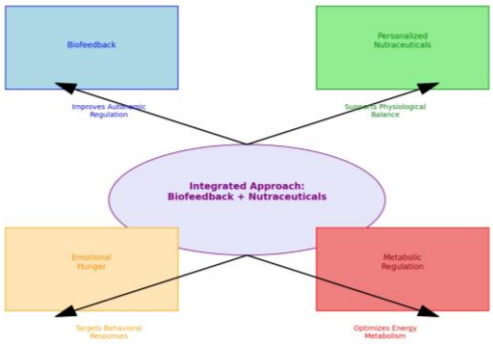

Figure 2: Integration nutrition model by Claudio Lombardo.

Nutraceuticals complement the intervention, offering targeted support for each autonomic state. The concept of using specific supplements to directly regulate autonomic states may expand the field of nutraceuticals, making it more targeted and effective.

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