Coll. Antropol. **32** (2008) Suppl. 2: 185–188
Review

Chromotherapy in the Regulation of Neurohormonal Balance in Human Brain – Complementary Application in Modern Psychiatric Treatment

Sanja Radeljak, Tija Žarković-Palijan, Dražen Kovačević and Marina Kovač

Department of Forensic Psychiatry, Neuropsychiatric Hospital »Dr. Ivan Barbot«, Popovača, Croatia

A B S T R A C T

Chromotherapy is based on the effect of colored light with different frequencies on human neurohormonal pathways, precisely on melatonin and serotonin pathways in brain. There is evidence that visible electromagnetic spectrum of light we see as colors can have impact on human health, Cicardian rhythm or biological clock is complex fundamental physiological and biological cycle in human organism. The biological clock in humans is located in the specialized group of brain cells called suprachiasmatic nucleus (SCN) within the anterior hypothalamus. The complex process of neurohormonal regulation of cicardian rhythm in humans is essential for synchronized interaction and coordination of internal body function with the environment. Given these facts it is clear that any shift in cicardian rhythm results in neurohormonal imbalance which consequently could lead to various psychiatric disorders affecting humans. Studies on sleep disorders, depression, seasonal affective disorder (SAD) and post-traumatic stress disorder (PTSD) suggested that symptoms, signs, and biologic markers associated to these psychiatric disorders are due to marked alterations in melatonin and serotonin levels. The main hypothesis of chromotherapy is that specific colors of the visible spectrum are activators or inhibitors of complex physiological, biological and biochemical processes in human brain such as synthesis of various neurohormons. According to all previous findings, our goal is future investigation of the effect and possible application of chromotherapy in the complementary psychiatric treatment in patients with diagnostic criteria which are clearly related to melatonin and serotonin disturbances.

Key words: *chromotherapy, chronobiology, neurohormonal pathways, melatonin, serotonin, cycardian rhythm, psychiatric disorders, psychiatric treatment*

Historical Aspects of Chromotherapy

Chromotherapy was originally discovered and developed by the ancients (Greece, China and Egypt) around 4000 years B.C. Paracelsus, the ancient physician in the period of renaissance regarded light and colors as essential to human health and used them in medical treatments for various human disorders. In 1666, the famous physicist Sir Isaac Newton discovered the visible electromagnetic spectrum of colors – the »color wheel« created by transmission of pure light trough a prism. Segments of colors were arranged around the circle in the same order created by the prism (red, orange, yellow, green, blue, violet). In the 1876, dr. August Pleasenton found the effect of colors on plants, animals and humans. In 1877, dr. Edwin Babbitt advanced the comprehensive theory of healing with colors. Scientific and medical aspects of chromotherapy were explained in 1940 by the Russian scientist dr. S.V. Krakov who originally established the theory of various color effects on sympathetic and parasympathethic nervous system in humans which led to rapid development of photobiology and chronobiology. In 1958, dr. Gerard found different psychotropic (psychoactive) effects of colors on human mood and behavior[1]. In

Received for publication July 30, 2008

1970, NASA research team of scientists discovered photodynamic therapy (PDT) as a result of development of light emitting diode technology (LED). It was confirmed lately that PDT can speed wound healing and activate light sensitive cancer drugs[1,2,9]. On the other hand, it was found that LED produced red light can reduce pain of the radiation therapy in patients on breast cancer treatment[9].

The Fundamental Basis of Chromotherapy

The fundamental mechanism of action of light and electromagnetic field on various physiological processes in humans is based on the fact that different light frequencies produces colors of the visible spectrum and colored light may be able to influence the internal structure of water, the main component of human organism[1,2,7,8]. This hypothesis is linked to recent suggestions by Tiller et al.[7], that so-called žwater-memory' originates in the internal structural arrangements of its hydrogen-bond linked oxygen atoms. Chromotherapy is based on the effect of colored light with different frequencies (in the visible spectrum) on human neurohormonal pathways, precisely on melatonin and serotonin pathways in brain[3,8]. Color is the perceived wavelengths of the visible electromagnetic spectrum (400–700 nm). Since electromagnetic wavelengths below red (infrared, radio and microwaves) and above violet (UV, X-rays, Gamma rays) have a physiological effects on humans, there is evidence that visible electromagnetic spectrum of light we see as colors can have impact on human health[1–9].

Cicardian Rhythm – Biological Clock

Cicardian rhythm is complex fundamental physiological and biological cycle in human organism. Since the early experiments, chronobiology (the study of biological rhythms) has become established as an interdisciplinary field within biology. Most chronobiologists studied circadian rhythms, endogenous cycles of human behavior or biological activity with a period of about 24 hours. In the example, the human sleep-wake cycle has a period of 1 day, or goes through 1 complete cycle in a day[1,2]. The mechanism of cicardian rhythm is based on constant daily cyclic changes and fluctuations in concentrations and levels of neurohormons in the brain, mainly in melatonin and serotonin levels[3]. Melatonin and serotonin are one of the most important neurohormons in the complex regulation of basic physiological functions in human organism such as sleep-awake cycle, blood pressure, heart rate, temperature, etc. Moreover, the complex process of neurohormonal regulation of cicardian rhythm in humans is essential for synchronized interaction and coordination of internal body functions with the environment[1,3,8]. Taken together, all scientific data strongly indicate that complex neural networks of serotonin and melatonin production and secretion in human brain are essential for keeping and maintaining the balance of cycardian rhythm or biological clock in humans. Biosynthesis and secretion of melatonin and serotonin in brain maintains human biological clock working, mainly by keeping the day and night cycle in constant balance which is necessary for human health and well being[12]. Given these facts it is clear that any shift in cicardian rhythm results in neurohormonal imbalance and *vice versa* which consequently could lead to various disorders affecting humans. Recent research on melancholia, depression, seasonal affective disorder (SAD) and post-traumatic stress disorder (PTSD) suggested that symptoms, signs, and biologic markers in those type of psychiatric disorders are due to marked alterations in melatonin and serotonin levels in brain, with the resultant increase of monoamine oxidase activity and consequently increase in plasma cortisol levels, which in turn lead to disturbance of sleep physiology[3–5]. High cortisol levels are found in chronic stress, PTSD, depression, memory impairment and sleep disorders[4,5]. In the same study author suggested that, according to results of his research, tryptophan and melatonin given shortly before bedtime could be rational treatment for melancholia and mild depression with sleep deprivation. Furthermore, the research on bright light therapy on mood disorders showed it could be effective in treatment of seasonal affective disorder because it markedly strengthens the biological clock that controls cicardian rhythms in human beings[4–6].

Production of Melatonin and Serotonin in Human Brain – Location of Biological Clock

The biological clock in humans is located in the suprachiasmatic nucleus (SCN), a distinct group of cells found within the hypothalamus. SCN is located in the anterior hypothalamus. SCN is body cicardian pacemaker or biological clock. SCN receives signals from the outside world via retinal cells and signals are transmitted by retino-hypothalamic tract to pineal gland, the main site of melatonin production. The SCN is known to have hormone receptors for melatonin (MT1, MT2), so there neural circuit from the pineal back to the SCN. It appears that the SCN takes the information on day length from the retina, interprets it, and passes it on to the pineal gland, which secretes melatonin in response to this message. Melatonin is an end product of biosynthetic pathway of serotonin synthesis. Biosynthetic pathway of both neurohormons begins with amino acid 5-hydroxytryptophan (5-HTP) which is partially converted to serotonin and to melatonin trough series of enzyme catalyzed reactions. Nighttime causes melatonin secretion to rise, while daylight inhibits it and trigger serotonin production and secretion. The perfect balance of melatonin and serotonin production cycle is essential for keeping the balance of sleep-awake cycle and maintaining the biological clock in humans. Even when light factors are absent (in dark chamber), melatonin and serotonin are still released in a cyclic manner; yet if the SCN is destroyed, circadian rhythms disappear entirely. The SCN plays the main role in the circadian system by trig-

gering a neuro-endocrine response in the hypothalamus, which then acts on the pineal gland and pituitary causing release of different neurohormons. The SCN triggers the hypothalamus, which activates the anterior pituitary to release other hormones such as corticotropin (ACTH), causing the adrenal glands to release cortisol which in turn plays crucial role in prolonged stress[12].

Biological Role of Melatonin

Researchers now use melatonin levels as an accurate marker of the circadian rhythm in humans. Melatonin is a chronobiotic molecule, central nervous system depressant and it is produced during the night by the pineal gland in brain. Melatonin exerts its biological effect by binding to specific melatonin receptors (MT1, MT2) on the cell surface and interfering with various cell receptors and small signaling molecules[8,11]. Broad spectrum of biological effects regulated by melatonin include regulation of cell proliferation and differentiation trough interaction with epidermal growth factor (EGF) receptors on the cell surface and downstream regulation of cell signaling molecules known as mitogen kinase system (MEK/ERK) which in turn regulate early gene expression in the cell nucleus[8,12]. Furthemore, melatonin exerts its role as potent anti-oxidative agent in cell via calmodulin complex which up-regulates anti-oxidative enzymes and acts as free radical scavenger. Melatonin is a »chronological pacemaker«, regulating cycardian rhythm with its central role in sleep regulation, although many different cellular biological functions are confirmed to be regulated by melatonin (cell signaling, cytoprotection, antioxidant, immunomodulation, antiapoptotic)[10]. In the central nervous system, melatonin acts as an inhibitory neurotransmitter, preventing neuronal excitation and has anxiolytic and hypnotic properties. Numerous studies have confirmed altered melatonin levels in depressed patients and other mood disorders such as bipolar disorder, dysthimic and cyclothimic disorder[6,12]. Altered melatonin levels are found in patients with chronic sleep disorder (dyssomnias) and post-traumatic stress disorder (PTSD)[4].

Biological Role of Serotonin

Serotonin is an excitatory neurotransmitter, secreted during daylight in human brain. Serotonin is known as one of the most important regulators of the numerous neuronal pathways in brain which are necessary for normal brain function. The synthesis and level of serotonin in brain is highest during daylight. Any disturbance in serotonin production could result in various psychiatric disorders. Low levels of serotonin in brain result in mood disorders such as major depressive episode, bipolar disorder, cyclothimic and dysthimic disorder and PTSD. High levels of serotonin are responsible for hallucinogenic states otherwise typical for schizophrenia and other psychotic disorders[12].

Research of the Color Effect on Human Behavior

Research on color impact on human psychological processes such as behavior and mood changes has confirmed several findings: the research on the effect of chromotherapy on the behavior of prisoners in the American penal system have shown that colors of specific spectrum such as pink light have calming effect as it suppresses hostile, aggressive and violent behavior among inmates. In contrast, the research of the yellow spectrum of light on the streets of major American cities has been linked to violence and criminal behavior during night[1,2,6].

Human Brain Research

Human brain research has shown post-mortal deep structural alterations and pathological changes in the brain of persons which were sleep deprived for numerous years. Sleep deprivation (dyssomnias) are related to melatonin and serotonin imbalance and consequently results in complete disturbance in cicardian rhythms causing serious alterations in balance of human biological clock. Dyssomnias are related to various psychiatric disorders such as major depression, bipolar disorder, PTSD, schizophrenia and various psychotic disorders[4,5,9]. Long term sleep deprivation leads to brain atrophy caused by serotonin and melatonin producing brain cells destruction[6,8,12].

Discussion and Conclusion

The main hypothesis of chromotherapy is that specific colors of the visible spectrum are activators or inhibitors of complex physiological, biological and biochemical processes[1,2,6,8] in human brain such as synthesis of various neurohormons, precisely melatonin and serotonin. Previous studies have confirmed that certain parts of brain are light sensitive and respond differently to different wavelengths of visible light spectrum (colors)[1,2,7]. The exact mechanism is based on the stimulation of deep brain structures namely hypothalamus, pituitary and pineal gland by transduction of electromagnetic field trough the visual pathway via retino-hypothalamic tract. The synthesis of melatonin and serotonin is regulated by hypothalamic-pituitary axis which plays crucial role in mediating and maintaining neurohormonal balance in human brain[12]. In general, every disturbance in the complex circle of hypothalamic-pituitary pathways results in imbalance of melatonin[3,10,11] and serotonin[8,12] production which in turn could result in various psychiatric disorders such as SAD, depression, bipolar disorder, PTSD, sleep disorders including brain atrophy classified according to DSM-IV diagnostic criteria[4,5,9]. According to previous findings[1–12], our goal is future investigation of the effect and possible application of chromotherapy in the complementary psychiatric treatment in patients with diagnostic criteria which are clearly related to melatonin and serotonin disturbances.

REFERENCES

1. AZEEMI ST, RAZA SM, Evid Based Complement Alternat Med, 2 (2005) 481. — 2. HANKEY A, EWING E, Adv Acc Pub, 4 (2007) 139. — 3. PERUMAL-PANDI SR, FEBS Journal, 273 (2006) 2813. — 4. HANKEY A, Evid Based Complement Alternat Med, 3 (2007) 131. — 5. MAURIZI CP, Med Hypotheses, 27 (1988) 271. — 6. PERRY R, Scientific documentation on color therapy, accessed 15.07.2008. Available from: http://www.rachelperry.net/SCIENTIFIC.html. — 7. TILLER R, BELL I, HOOVER MR, Mater Res Innov, 9 (2005) 93. — 8. HANKEY A, Evid Based Complement Alternat Med, 2 (2005) 5. — 9. HANKEY A, Evid Based Complement Alternat Med, 3 (2006) 139. — 10. FISCHER S, SMOLNIK R, HERMS MJ, BORN J, FEHM HL, J Clin Endocrinol Metab, 88 (2003) 5315. — 11. REPPERT SM, WEAVER DR, RIVKEES SA, STOPA EG, Science, 242 (1988) 78. 12. AUGUSTINE GJ, FITZPATRICK D, KATZ CL, LAMANTIA AS, MCNAMARA JO, WILLIAMS SM, Molecular Mechanism of Biological Clock (Sinauer Associates, Sunderland, 2001).

S. Radeljak

Department of Forensic Psychiatry, Neuropsychiatric Hospital »Dr. Ivan Barbot«, Popovača, Croatia
e-mail: sanjaradeljak@aol.com

KROMOTERAPIJA U REGULACIJI NEUROHORMONALNE RAVNOTEŽE U LJUDSKOM MOZGU – KOMPLEMENTARNA PRIMJENA U MODERNOM PSIHIJATRIJSKOM LIJEČENJU

SAŽETAK

Kromoterapija se temelji na učinku obojenog svjetla različitih valnih dužina i frekvencija na neurohormonalni sustav melatonina i serotonina u ljudskom mozgu. Istraživanja su pokazala da elektromagnetski spektar svjetla, koji ljudsko oko vidi kao spektar boja, može imati utjecaj na ljudsko zdravlje. Cikardijski ritam ili biološki sat je složeni fundamentalni proces koji se odnosi na fiziološke i biološke cikluse u ljudskom organizmu. Biološki sat je kod čovjeka smješten u dubokim strukturama srednjeg djela mozga i odnosi se na specijaliziranu grupu živčanih stanica tzv. suprahijazmatsku jezgru (SCN) koja se nalazi u prednjem dijelu hipotalamusa. Neurohormonalna regulacija cikardijskog ritma je složeni proces koji je neophodan za usklađenu koordinaciju i interakciju unutarnjih funkcija ljudskog organizma s okolišem. Vezano za sve navedene činjenice može se zaključiti da svaki pomak u usklađenosti cikardijskih ritmova odnosno biološkog sata može dovesti do narušavanja neurohormonalne ravnoteže melatonina i serotonina u ljudskom organizmu i posljedično do niza psihijatrijskih poremećaja. Istraživanja o poremećajima spavanja i afekta vezanih za godišnja doba kao i istraživanja depresivnih poremećaja i posttraumatskog stresnog poremećaja pokazala su da se simptomi i biološki markeri ovih poremećaja mogu objasniti značajnim promjenama u razini melatonina i serotonina u mozgu. Glavna hipoteza kromoterapije temelji se na činjenici da su određene boje vidljivog spektra aktivatori ili inhibitori složenih fizioloških, bioloških i biokemijskih procesa u ljudskom mozgu kao što je sinteza različitih neurohormona. S obzirom na sva dosadašnja istraživanja i rezultate koji iz toga proizlaze, naš cilj je buduće proučavanje učinka i moguće aplikacije kromoterapije kao komplementarnog načina liječenja u psihijatriji kod pacijenata s jasnim dijagnostičkim kriterijima psihijatrijskih poremećaja koji su usko povezani s narušenom ravnotežom melatonina i serotonina u mozgu.