MedCrave
Step into the World of Research
Endocrinology & Metabolism International Journal

Mini Review
Open Access
CrossMark

Chronobiological interactions of stress and disease: contribution to hormonal regulation in the ontopathogenic model

Abstract

This mini-review describes interactions of hormonal stress mediators and some age-related disorders in a chronobiological mode. In addition, historical aspects of chronobiology, as well as biorhythmological topics related to development and aging are briefly discussed.

Keywords: age-related disorders, hormonal biorhythms, ontopathogeny, stress

Volume 11 Issue 3 - 2023

Viktor I Goudochnikov
PhD in Biochemistry, Member of ISOAD, Brazil

Correspondence: Viktor I Goudochnikov, PhD in Biochemistry, Member of ISOAD, Rua Matoso Camara 73, Bairro Menino Jesus, CEP 97050-500, Santa Maria – RS, Brazil, Tel +5555991310805, Email victori40@hotmail.com

Received: December 04, 2023 | **Published:** December 15, 2023

Abbreviations: ACTH, adrenocorticotropic hormone; CRH, corticotropin-releasing hormone; DOHaD, developmental origins of health and disease; GC, glucocorticoids; HPA, hypothalamic-pituitary-adrenal (axis)

Introduction

For many decades the homeostatic concept dominated endocrinology completely, considering feed forward and feedback relations in the schemes of hormonal regulation. For example, these relations are discussed also, as referred to hypothalamic-pituitary-adrenal (HPA) axis, with corticotropin-releasing hormone (CRH) and arginine-vasopressin of hypothalamus stimulating secretion of adrenocorticotropic hormone (ACTH) in anterior pituitary, and ACTH in turn stimulating secretion of glucocorticoids (GC) in adrenal cortex, whereas GC inhibit the secretion of CRH and ACTH.[1] However, this conventional scheme does not include the latest data on biorhythms of hormonal secretion. In fact, both circadian and ultradian rhythms of hormones in HPA axis are already well known.

On the other hand, with the advent of DOHaD (developmental origins of health and disease) concept, GC were considered as principal candidates for the role of hormonal mediators in the phenomena of programming/imprinting and embedding, when stressful events during pre- and postnatal development cause long-term consequences till adult state and perhaps, even till senescence, via GC provoking somatic and organ growth retardation and thus the increase in predisposition to cardiometabolic and other age-related disorders.[2]

In the present article we shall try to adjust these theoretical considerations, introducing chronobiological topics, not widely discussed yet in DOHaD paradigm. In order to do this, we shall use the terms "ontopathogeny" and "ontopathogenic model", based on DOHaD concept and describing etiopathogeny along the whole ontogeny or at least its main part.[3]

Some historical aspects of chronobiology

As related to biorhythms in animals and humans, the cardinal event occurred in 1960 at the Conference in Cold Spring Harbor, USA.[4] Since then and during the next 50 years the outstanding leader of research in this area was American scientist Franz Halberg, who is considered as chronobiology "father", creating cosinor methodology for studying principally circadian rhythms (i.e. with a period close to 24 h), as well as the terms "ultradian" (with a period lower than 24 h), "infradian" (with a period higher than 24 h) and many others, publishing a great number of articles and promoting biorhythmology in many countries.[5,6]

What for HPA axis, circadian rhythms of hormonal secretion in it are well known since the second half of the last century, with cortisol in humans attaining its maximum in the morning, shortly after awakening and nadir in the evening, close to midnight. However, the interactions between GC and other stress hormones, especially catecholamines, adrenaline (epinephrine) and noradrenaline (norepinephrine) in various biorhythms are less known. Moreover, infradian rhythms of HPA axis were much less studied till the present moment. Therefore, in our article we would like to summarize some scarce data particularly on GC, in order to demonstrate nice perspectives of this approach in near future.

The role of circadian biorhythms of stress hormones in pathogeny of various diseases

At first, we should outline that important contributions of GC to etiopathogenic mechanisms of age-related cardiometabolic and neuropsychiatric disorders are already well known.[7–9] Here we pretend to add some essential details to these descriptions.

In fact, it is already firmly established that the frequencies of ischemic heart disease, acute myocardial infarction and stroke are higher in the morning,[10,11] and this is probably related to higher levels of GC and catecholamines. Moreover, some authors even affirm that elevated GC levels shortly after awakening suggest that each morning represents a stressful period of the day, at least for the patients.[12]

Besides GC, several other hormones are involved in circadian biorhythms influencing predisposition to cardiovascular disorders. In fact, it is proposed that sympathetic – vagal balance in autonomic nervous system is biased to sympathetic predominance during the day and to vagal predominance at night,[13] thus accompanying circadian oscillations of GC.

On the other hand, normally melatonin levels are higher at night and lower during the day. Since melatonin may be considered as

anti-stress hormone, it explains why elevated GC concentrations and diminished concentrations of melatonin are important in the pathogeny of depressive disorder,[14] especially in shift workers, including those in health care.

What for hypertension, here two types of patients were described: dippers and non-dippers, depending on the existence or not of decrease in blood pressure at night. It appears that especially in dippers higher blood pressure in the morning may correspond to elevated levels of cortisol and catecholamines, provoking greater predisposition to acute cardiovascular events in this part of the day and the necessity to use anti-hypertensive pharmacotherapy destined to control better blood pressure in the morning.[15] On the other hand, non-dipper type of hypertension is secondary one and usually more severe, e.g. due to renal disease. In this case preferred control of blood pressure should be in the evening and at night.[16]

In cancer treatment, it should be outlined that generally, circadian rhythms are largely disrupted in oncologic patients, and besides, maximal proliferation rates occur in different parts of circadian cycle for normal tissues and tumors, thus facilitating chronotherapy with various anti-cancer agents, using programmable infusion devices. These relatively new techniques allow for the usage of higher doses of chemotherapeutic agents, together with decrease in the incidence of their adverse effects.[17] However, interactions of stress hormones in circadian biorhythms need to be better explored in patients with various cancer types.

Since synthetic GC (hydrocortisone, prednisolone, dexamethasone and others) are widely used in various areas of clinical medicine, we should be aware that pharmacotherapeutic schemes employing them can significantly modify both biorhythms of endogenous GC and their actions on different physiological parameters during the day and night. This is also relevant for shift workers, particular in health care.[18]

Moreover, as related to shift work, we must consider the patient's chronotype, i.e. "morningness" and "eveningness", thus outlining the importance of chronopsychology. And finally interactions between stress hormones and stress proteins, like heat shock proteins should not be neglected, taking into account their possible roles in mechanisms of tiredness / fatigue and sleepiness.[18,19]

Some chronobiological aspects of development and aging

It appears that melatonin levels in maternal blood and breast milk help in entraining circadian rhythms in fetus and neonate, serving as both the clock and calendar, being dependent on the length of photoperiod.[20,21] However, interactions between melatonin and GC in circadian cycles are poorly understood yet, particularly during development.

What for aging, Franz Halberg was already greatly interested in its chronobiological topics, outlining also the importance of studying infradian rhythms for the incidence of cardiovascular disorders. Later, a French group working with primates of small size consistently demonstrated the important role of counting seasonal cycles, probably by means melatonin rhythms, for lifespan determination.[22–24] On the other hand, the essential role of infradian rhythms with a period close to one week for lifespan determination was shown in several species of mammals including primates.[25]

Conclusion

Earlier we have already affirmed that GC are strategically located at the crossroads of joint activities of 3 principal bioregulatory systems: nervous, endocrine and immune.[3] Now it is important to add chronobiological topics to this description, at least as referred to circadian rhythms, in order to clarify better the role of GC in the phenomena of programming / imprinting and embedding in the ontopathogenic model.

Acknowledgments

None

Conflicts of interest

Authors declare that there is no conflict of interest exists.

Funding

None.

References

1. Goudochnikov VI, Santos Goudochnikov NV. Different types of stress as highly complex endocrine and biochemical phenomena: A reappraisal. *Open Access Journal of Endocrinology*. 2022;6:000171.
2. Goudochnikov VI. Central positions of glucocorticoids and stress in the phenomena of hormonal and metabolic programming/imprinting. *Journal of Endocrinological Science*. 2023;5:1–7.
3. Goudochnikov VI. The contribution of stress and its mediators to the ontopathogeny of infections: A focus on the interactions of cytokines and glucocorticoids. *Advances in Gerontology*. 2017;7:25–28.
4. Munoz MC, Ojea AM, Gonzalez AC, et al. Chronobiology and cancer. *Oncologia*. 2004;27:279–288.
5. Refinetti R, Cornelissen G, Halberg F. Procedures for numerical analysis of circadian rhythms. *Biological Rhythm Research*. 2007;38(4):275–325.
6. Cornelissen G, Halberg F, Halberg J, et al. Remembering Franz Halberg MD (July 5, 1919 – June 9, 2013). *Journal of Experimental Therapeutics and Oncology*. 2013;10(3):239–242.
7. Goudochnikov VI. Role of glucocorticoids and stress in pathogeny of diabetes mellitus and related disorders. *Journal of Diabetes and Metabolic Disorders*. 2018;5:022.
8. Goudochnikov VI. The role of stress and glucocorticoids in pathogeny of age-related neuropsychiatric disorders. *Journal of Geriatric Medicine and Gerontology*. 2018;4(3):054.
9. Goudochnikov VI, Santos Goudochnikov NV. The role of stress and its hormonal mediators in the ontopathogeny of cardiovascular disorders. *MedPress Cardiology and Vascular Medicine*. 2022;2:202204001.
10. Kumagai Y. Strategies against high blood pressure in the early morning. *Clinical and Experimental Hypertension*. 2004;26(2):107–118.
11. Willis TA, O'Connor DB, Smith L. The influence of morningness – eveningness on anxiety and cardiovascular responses to stress. *Physiology and Behavior*. 2005;85(2):125–133.
12. Fernandes EH, Coelho D, Correa JRM, et al. Circadian alterations of cardiovascular system. *Revista Espanola de Cardiologia*. 2000;53:117–122.
13. Yun AJ, Lee PY, Bazar KA. Temporal variation of autonomic balance and diseases during circadian, seasonal, reproductive and lifespan cycles. *Medical Hypotheses*. 2004;63:155–162.
14. Smeraldi E. Circadian rhythms and bipolar depression. *Medicographia*. 2007;29:38–43.
15. Lemmer B. The importance of circadian rhythms on drug response in hypertension and coronary heart disease – from mice and man. *Pharmacology and Therapeutics*. 2006;111(3):629–651.

16. Smith DHG. Pharmacology of cardiovascular chronotherapeutic agents. *American Journal of Hypertension*. 2001;14:296S–301S.

17. Levi F. From circadian rhythms to cancer chronotherapeutics. *Chronobiology International*. 2002;19:1–19.

18. Goudochnikov VI. Shift workers in health care: Endocrine age-related mechanisms of morbidity and mortality in the ontopathogenic model. *Endocrinology and Metabolism International Journal.* 2023;11(2):48–51.

19. Goudochnikov VI. Role of stress proteins and hormones in bioregulation of ontogeny. *Problemy Endokrinologii*. 2015;61:49–53.

20. Mirmiran M, Ariagno RL. Influence of light in the NICU on the development of circadian thythms in preterm infants. *Seminars in Perinatology*. 2000;24(4):247–257.

21. Natale V, Adan A, Chotai J. Further results on the association between morningness – eveningness preference and the season of birth in human adults. *Neuropsychobiology*. 2002;46;209–214.

22. Perret M. Change in photoperiodic cycle affects life span in a prosimian primate (Microcebus murinus). *Journal of Biological Rhythms*. 1997;12(2):136–145.

23. Aujard F, Dkhissi-Benyahya O, Fournier I, et al. Artificially accelerated aging by shortened photoperiod alters early gene expression (Fos) in the suprachiasmatic nucleus and sulfatoxymelatonin excretion in a small primate, Microcebus murinus. *Neuroscience*. 2001;105(2):403–412.

24. Cayetanot F, Van Someren EJW, Perret M, et al. Shortened seasonal photoperiodic cycles accelerate aging of the diurnal and circadian locomotor activity rhythms in a primate. *Journal of Biological Rhythms*. 2005;20(5):461–469.

25. Bromage TG, Idaghdour Y, Lacruz RS, et al. The swine plasma metabolome chronicles "many days" biological timing and functions linked to growth. *Plos One*. 2016;11:e0145919.

Citation: Goudochnikov VI. Chronobiological interactions of stress and disease: contribution to hormonal regulation in the ontopathogenic model. *Endocrinol Metab Int J.* 2023;11(3):79–81. DOI: 10.15406/emij.2023.11.00336