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ORIGINAL ARTICLE

Seasonal Factors of Adaptation of Water-Mineral Chronoperiodical System in Healthy Individuals and Patients With Syndrome of Vegetative Dystonia

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Objective: The aim of this study was to examine the peculiarities of various components of water-mineral chronoperiodical system under the action of seasonal factors in practically healthy individuals and in patients with the syndrome of vegetative dystonia (SVD). **Methods:** Forty practically healthy individuals and 38 ambulatory patients with SVD were investigated. Practically healthy subjects and patients with SVD were on identical regimen (sleep, wake, and diet). Four-hour urine specimens were collected over a period of 72–120 hours, with duration of 4–5 days. Each sample of urine was analyzed for electrolytes and some microelements. Temporal organization (biological and weather factors) parameters have been measured by nonlinear least squares method for the rhythms with sinusoidal structure and dispersion analysis for the rhythms with non-sinusoidal organization. Parameters of weather factors were received from the hydrometeorological service of Yerevan, Armenia. **Results:** Healthy subjects were characterized with the circadian structure of macro and microelements chronoperiodical system. Acrophases of the biorhythms were individual, and were outstripping the acrophases of the weather indices' oscillations. **Conclusion:** Chronostructure of macro- and microelement homeostasis in patients with SVD were characterized with infradian oscillations. For patients with SVD, significant correlation between rhythms of electrolytes and trace elements and oscillations of weather factors was different in comparison with the data for healthy subjects. In patients with SVD, acrophases of chronoperiodical system of electrolytes and microelements frequently were concurrent relative to the acrophases of fluctuations of the weather factors.

Keywords: Mesor; Hydrometeorological indices; Amplitude; Biological rhythm; Acrophase

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INTRODUCTION

The impact of variation in the geomagnetic field and a weather factors on the human body remains the subject of studies across the world, yet there is no consensus.

Temporal organization and dynamics of bio-fluctuations evolved in the process of evolution under the influence of environmental factors [1-6]. Circadian chronoperiodical systems had been considered as fundamental oscillation. Convincing data about electrolytes and trace elements metabolism disturbance in patients with the hypertensive disease, ischemic heart disease, and syndrome of vegetative dystonia (SVD) at different stages of its development have been obtained by different authors [7-10]. However, the results of these investigations contradict each other.

These investigations were mostly carried out without taking into consideration the temporal organization of an organism. Chronobiological research indicated that many pathological functions are accompanied by disorders of chronoperiodical system of an organism [11-18]. The SVD is a polyetiological and functional pathology of the cardiovascular system. On the basis of the SVD, a disturbance of neuroendocrine regulation with various clinical symptoms was observed.

The purpose of this investigation was to examine the peculiarities of various components of water-mineral chronoperiodical system under the action of seasonal factors in practically healthy individuals and in patients with the SVD.

METHODS

Forty practically healthy individuals (20 female, 20 male) and 38 ambulatory patients (18 female, 20 male) with SVD were investigated. The average age of healthy individuals was 32.33±3.7 years and the average age of patients with SVD was 31.53±3.5 years. Individuals with SVD and practically healthy subjects were on identical regimen (sleep, wake, and diet). The patients with SVD were characterized by cardiological cerebrovascular syndromes and marked meteo-sensitivity. The basis of diagnosticating SVD was the exception of the pathology which had analogical symptoms. The marker of vegetative dysfunction was a disturbance of the circadian chronostructure of the function cardiovascular system. Especially disturbance of circadian rhythms of heart rate variability (HRV), time-domain indices, and frequency domain measures. Four-hour urine specimens were collected over a period of 72−120 hours from healthy subjects and patients with SVD. Each specimen was analyzed for macroelements (sodium, magnesium, potassium, chlorine, phosphorus, calcium) and microelements (copper, cadmium, zinc, iron, vanadium, chromium) using the atomic absorption spectroscopy (AAS; Perkin-Elmer, Waltham, MA, USA). Phosphorus was analyzed with phosphorus kits (Viola LLC, Yerevan, Armenia), and chlorine was analyzed on Cobas b 121 System (Roche Diagnostics, Mannheim, Germany). Mesors (M) and amplitudes (A) of the temporal structure were calculated by the following units of measurement: volume of urine (mL/h); sodium, potassium, chlorine and phosphorus (mmol/h); calcium, magnesium, and zinc (μmol/h); and iron, copper, chromium, cadmium, and vanadium (nmol/h). Parameters of fluctuations (biological and weather factors) have been appraised by nonlinear least squares method for sinusoidal fluctuations and dispersion analysis for non-sinusoidal fluctuations [19-21]. The parameters of the rhythms were grouped in accordance with international glossary of chronobiology, which were subjected to some changes [19-24].

The fluctuations with the interval of 3 to 20 hours were counted as ultradian, from 20 to 28 hours as circadian, and from 28 to 96 hours as infradian. From Hydrometeorological Service of Armenia, the data of hydrometeorological indices (HMI) were received at 3-hour intervals.

- The temperature of the air (TA, °C)
- The relative humidity of the air (RHA, %)
- The deficit humidity of the air (DHA, hPa)
- The atmospheric pressure (AP, hPa)
- The speed of the wind (SW, m/s)
- The general cloudiness (GC, Mark)

Biorhythmological analysis of the weather factots (TA, RHA, DHA, AP, SW, and GC) were conducted for the disclosure ultradian, circadian, and infradian rhythms during 168−240 hours. Informed consent was obtained from all participants. A detailed explanation of the study protocol was given to the participants according to the Declaration of Helsinki Principles.

RESULTS

The results showed that the condition of the fluctuations of DHA, RHA, and TA in 2015 in Yerevan, Armenia had circadian nature. Temporal organizations of AP and GC were not statistically significant. Fluctuations of SW had circadian and infradian nature and for GC ultradian nature.

For realization of correlative investigation, we measured macro- and trace elements in urine. Measurements were done within 72−120 hours, at 3-hour intervals. After we used sliding method with the same 72−120 hours, previous and following 48 hours (the whole 160−216 hours) at 3-hour intervals measuring of HMI (TA, RHA, DHA, AP, SW, GC). Investigations were carried out by Spirmen method with sliding data of each electrolyte and microelement with the data of each HMI at 3-hour intervals. The presence of correlative connection between biorhythms and rhythms of HMI was considered statistically significant with correlation coefficient 0.5 and more. Since the data for HMI was registered at 3-hour intervals, 4-hour data of urine, electrolytes and microelements were adjusted with the interpolation plan. Correlative connections of indices have been investigated considering the outstrip or delay of the acrophases of indices of macro- and microelements homeostasis in relation to the acrophases of fluctuations HMI. The results showed that the healthy subjects' electrolytes and trace elements excretion temporal organizations were statistically significant in 91%. In healthy subjects, the circadians prevailed among the significant rhythms (84%). The results showed that in the healthy individuals 3.6% electrolytes and trace elements excretion temporal organizations were non-sinusoidal. Therefore, healthy individuals were characterized with the circadian structures and with definite value parameters of temporal organizations (M and A) within the confidence limit (Figure 1). Acrophases of the rhythms were individual and not definite for the total group of the healthy individuals. Our data witnessed that in healthy subjects' water-minerals excretion rhythms had statistically significant coefficient of correlation (91%) with the rhythms of seasonal factors. Statistically nonsignificant correlative connections were between temporal structures of zinc, vanadium and TA; chromium, cadmium and RHA; zinc, vanadium and DHA; copper, zinc and AP; magnesium, zinc, vanadium and CW; zinc and GC. The results showed that in healthy individuals, the acrophases of the temporal organizations of excretion of water-mineral indices were outstripped (73%) to the acrophases of rhythms HMI (Figure 2). In healthy individuals, acrophases of biorhythms in 15% of cases occurred simultaneously with the acrophases of HMI rhythms. Healthy subjects were characterized with the circadian structure of macro- and microelements homeostasis and with different value of M and A. Acrophases of the rhythms were individual. In healthy subjects acrophases of electrolyte and microelement homeostasis outstripped to the acrophases of rhythms HMI (Figure 2). Our results showed that in the healthy subjects the rhythms of electrolytes and trace elements homeostasis were sinusoidal and circadian. Our data indicated that in healthy subjects' water-mineral homeostasis rhythms had statistically significant correlative connections with the rhythms of HMI. In patients with SVD in 140 (35%) cases of 402 rhythmological investigations urinary excretion electrolytes and trace elements statistically significant temporal organizations were not observed. In patients with SVD among the statistically significant rhythms the infradian (36%) prevailed (Figure 1) and A of phosphorus oscillations were significantly higher than in the healthy individuals (Table 1). Our results indicated that M and A of calcium were statistically

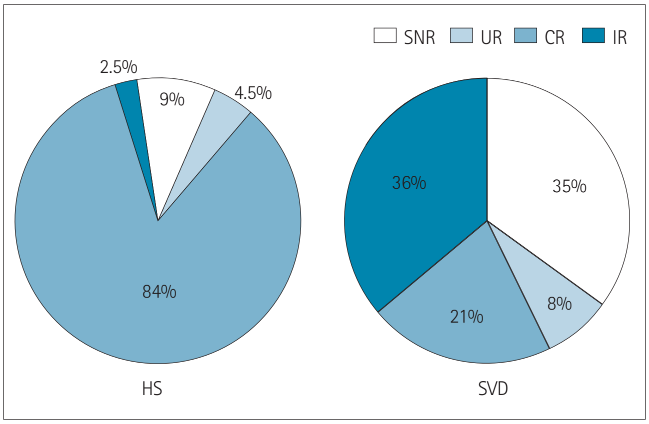

Figure 1. Summary data of distribution (%) of ultradian (UR), circadian (CR), and infradian (IR) rhythms of statistically significant temporal organizations of water-mineral homeostasis in HS and in patients with SVD. HS, healthy subjects; SVD, syndrome of vegetative dystonia; SNR, statistically nonsignificant rhythms.

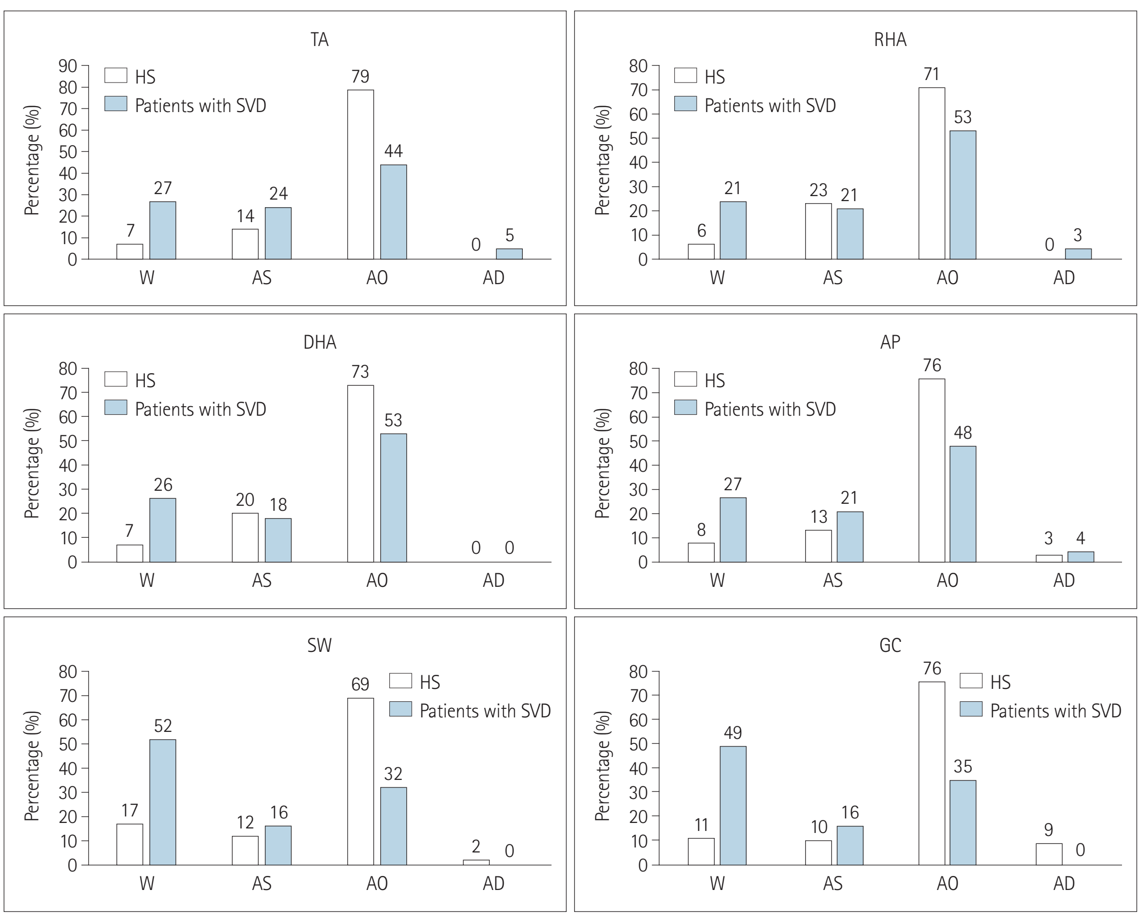

Figure 2. Summary data of the acrophase of excretion rhythms of macro- and microelements relative to the acrophases of HMI rhythms (TA, RHA, DHA, AP, SW, GC) in HS and patients with SVD. W, percentages of HS and patients with SVD with statistically nonsignificant correlative connections between rhythms of water-mineral homeostasis and HMI rhythms. AS, percentages of HS and patients with SVD with acrophases of water-mineral execration rhythms which occurred simultaneously with the acrophases of the HMI rhythms. AO, percentages of HS and patients with SVD with outstripped acrophases of water-mineral excretion rhythms relative to acrophases of the HMI rhythms. AD, percentages of HS and patients with SVD with delayed acrophases of water-mineral excretion rhythms relative to the acrophases of the HMI rhythms. HMI, hydrometeorological indices; HS, healthy subject; SVD, syndrome of vegetative dystonia; TA, temperature of the air; RHA, relative humidity of the air; DHA, deficit humidity of the air; AP, atmospheric pressure; SW, speed of wind; GC, general cloudiness.

Table 1. Mesors (M) and amplitudes (A) of urinary excretion of the electrolytes and trace elements and ultradian (U), circadian (C), and infradian (I) distribution of the statistically significant rhythms (S) in patients with syndrome of vegetative dystonia

Indices	S (%)	U (%)	C (%)	I (%)	M±SE	A±SE
Volume of urine	58***	14	31	55	36.25±1.66	11.22±0.77
Sodium	74***	22	22	56	5.72±0.34	1.89±0.75
Potassium	68***	15	41	44	186±0.14	0.67±0.06
Coefficient sodium/potassium	64**	9	50	41	4.24±0.71	1.35±0.38
Chlorine	60***	6	33	61	7.64±0.67	2.67±0.29
Calcium	67**	25	33	42	78.04±10.88*	31.24±5.87*
Magnesium	61*	26	11	63	54.89±12.72	19.75±4.68
Phosphorus	54***	6	22	72	2.36±0.23***	0.97±0.09***
Iron	67**	20	20	60	98.78±19.60	45.57±6.03
Copper	67*	0	30	70	46.96±10.32	14.03±2.67
Zine	60	11	11	78	0.26±0.04	0.13±0.03
Chromium	60	11	11	78	20.73±3.67	9.69±2.89
Cadmium	87	0	0	100	9.69±1.69	3.04±0.70
Vanadium	80	0	83	17	23.53±1.27	7.35±0.77

*p<0.05; **p<0.01; ***p<0.001 they were calculated comparably with data of the healthy individuals. M and A were calculated by the following unites—volume of urine: mL/h; sodium, potassium, phosphorus, chlorine: mmol/h; calcium, magnesium, zinc: μmol/h; iron, copper, chromium, cadmium, vanadium: nmol/h. SE, standard error

Table 2. Nature of statistically significant correlative connections (between rhythms of HMI and the rhythms of urinary excretion of macro- and microelements) in HS and patients with SVD for different seasons

Indices	Seasons	Nature of correlative connections	
		HS	SVD
TA & macro/micro-element	Summer	-	+
RHA & macro/micro-element	Winter	-	+
DHA & macro/micro-element	Autumn	-	+
AP & macro/micro-element	Spring	+	-
SW & macro/micro-element	Summer	+	-
GC & macro/micro-element	Winter	-	+

HS, healthy subjects; SVD, syndrome of vegetative dystonia; TA, temperature of the air; RHA, relative humidity of the air; DHA, deficit humidity of the air; AP, atmospheric pressure; SW, speed of wind; GC, general cloudiness

significantly lower than in the healthy subjects (Table 1). The data of patients with SVD have shown a 35% statistically nonsignificant correlative connections between their electrolytes and trace elements homeostasis and the temporal organizations of HMI (Figure 1). Statistically nonsignificant correlative connections in patient with SVD were considerably more (35%) in comparison with the results of healthy subjects (p<0.01). In patients with SVD, correlative connections between rhythms of cadmium and TA; calcium, magnesium, cadmium and RHA; calcium, cadmium and DHA; cadmium and AP were statistically significant. Our results indicated that in patients with SVD acrophases of temporal organizations of water-mineral excretion outstripped (44%) to the acrophases of the HMI rhythms (Figure 2). These results obviously were statistically significantly smaller in the comparison with the data of the healthy subjects (p<0.01). Our data indicated that patient with SVD acrophases of electrolytes and trace elements excretion rhythms in 19% cases were simultaneous with the acrophases of rhythms HMI (Figure 2). In patients with SVD indices of homeostasis of electrolytes and trace elements were characterized with less statistically significant correlative connections with rhythms of HMI in comparison with the data of healthy subjects. In patients with SVD, acrophases of water-mineral homeostasis often were simultaneous relative to the acrophases of the HMI rhythms (Figure 2).

DISCUSSION

Our data indicated that in healthy subjects' temporal structure of the macro- and microelements homeostasis was sinusoidal and circadian. It was an internal synchronization by periods of biorhythms [11-13]. We were unable to compare our data with the results of other researchers since similar investigations in healthy subjects and patients with SVD have not been found in available literature. Our results indicated that in healthy subjects, electrolytes and microelements chronoperiodical system had statistically significant correlative connections with the rhythms of HMI. It was an external synchronization by periods [14-16]. In healthy individuals, the acrophases of indices of water-mineral chronoperiodical system came before acrophses of the HMI (Figure 2). That results witnessed the outstripping meteo-adaptation of water-mineral chronoperiodical system of organism to the fluctuations of HMI. The character of correlative connections between fluctuations of HMI and oscillations of indices of water-mineral homeostasis in SVD essentially distinguished in comparison with the data of healthy subjects.

This data witnessed an external desynchronization by period of oscillations in SVD. In SVD, acrophases of temporal organizations of macro- and microelements homeostasis were simultaneous relative to the acrophases of HMI rhythms (Figure 2). That results indicated the direct impact on temporal organization of water-mineral homeostasis by the given HMI and decrease of adaptive possibilities of macro- and microelements homeostasis. The results non-rhythmological investigations were shown, that in SVD there is no changes of data of electrolytes and trace elements homeostasis in comparison to the results of heathy individuals. Thus, the changes of parameters of water-mineral excretion rhythms obtained diagnostic significance (Table 1). These data could also help in the organization of pathogenetic therapy in patients with SVD taking into account temporal structure of electrolytes and microelements homeostasis. The changes of urinary excretion function are adequate parameter for determination of meteo-sensitivity [25]. The results of investigations for correlative connections between the rhythms of HMI and temporal structures of urine and minerals excretion in healthy individuals and in SVD indicated that these connections had seasonal nature with positive or negative character. Healthy subjects' correlative connections between temporal structure of TA and excretion rhythms of electrolytes and trace elements characterized with negative nature in summer (in winter: between of biorhythms and rhythms of RHA, GC; in autumn: between of biorhythms and rhythms of DHA) (Table 2). Healthy individuals' correlative connections between temporal organization of AP and excretion rhythms of indices of water-mineral homeostasis characterized with positive nature in spring (in summer: between biorhythms and rhythms of SW) (Table 2). In SVD correlative connections between excretion rhythms of indices of macro- and microelements homeostasis and rhythms of HMI have revers mark in the same season of the year in comparison with the data of healthy subjects (Table 2).

Evolutionary, a human organism is adapted to the natural geomagnetic environment, weather factors, and its slight alteration. Every organism has specific sensitivity to the strength and frequency of oscillations of geomagnetic field and weather factors. We look forward that future investigations of chronoperiodical systems will determine these problems and will help to reveal the adequate parameters of meteo-sensitivity.

Funding Statement

None

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Availability of Data and Material

The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

Author Contributions

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