EXPERIMENTAL BIOLOGY

Seasonal Dynamics of Clinically Significant Metabolic Parameters in Northern Residents of Different Age

T. I. Kochan and T. V. Eseva

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 147, No. 6, pp. 700-703, June, 2009
Original article submitted November 29, 2007

One-year monitoring of the blood metabolic parameters in residents of the North (students aged 18-20 years and scientists aged 30-59 years) showed that blood concentrations of glucose, lactate, and albumin varied in young people (18-20 years) within a greater range throughout the year than in older subjects (30-59 years), while the range of variations for triglycerides and cholesterol concentration was lesser in young subjects. Despite age-specific differences in metabolism, the seasonal dynamics of metabolite concentrations conforms to common regularities. The contribution of anaerobic glycolysis to the maintenance of energy homeostasis is greater during the fall-winter period, which leads to reduction of glycemic level to the lowest threshold normal level and to lactatacidosis. The concentrations of triglycerides increase significantly in winter, which indicates intensification of lipogenesis. Gluconeogenesis and aerobic oxidation of reserve lipids are intensified in the winter-spring period.

Key Words: *human; metabolism; adaptation; North*

Despite numerous studies of seasonal fluctuations in metabolism and functioning of physiological systems in humans under conditions of the North [1-4,6,7,10,12-14], the mechanism of adaptation to the extreme natural factors remains little studied. The main cause of this is the absence of regular research carried out on the same object with consideration for the specific natural and social factors. The knowledge of the mechanisms of metabolic adaptation to changing environmental conditions is an approach to understanding of the most vulnerable sites in metabolism and of causes of human disease. Study of seasonal metabolism is particularly interesting in subjects of different age, as deviations from physiological norm are observed in residents of the North at an earlier age. Importantly that it is not always possible to identify which shifts in the functioning of this or that body system are caused by adaptation and which are signs of disease.

We studied seasonal dynamics of carbohydrate, lipid, and protein metabolism in two socially homogeneous age groups of residents of the North.

MATERIALS AND METHODS

The study was carried out in 2 groups of healthy individuals, urban residents, engaged in intellectual work and living in the North (62^o Northern latitude): students aged 18-20 years (group 1) and scientists aged 30-59 years (group 2; Table 1). The blood was collected from the ulnar vein after overnight fasting into vacutainers. Plasma concentrations of glucose, lactate, triglycerides (TGC), total cholesterol (TCS),

Department of Ecological and Social Human Physiology, Institute of Physiology, Komi Research Center, the Russian Academy of Sciences, Russia. ***Address for correspondence:*** kochan0707@mail.ru. T. I. Kochan

0007-4888/09/1476-0757 © 2009 Springer Science+Business Media, Inc.

and albumin were measured by universal colorimetrical methods using Chronolab kits. Actual nutrition was studied by 24-h reproduction of nutrition based on the Album of Foodstuff Portions and Dishes, developed by the Institute of Nutrition of the Russian Academy of Medical Sciences [9]. The weather and daylight length were regularly recorded.

The significance of differences was evaluated using Student's *t* test.

RESULTS

The concentrations of glucose, lactate, and albumin in the blood of young subjects varied greater, while the levels of TGC and TCS varied less than those in the older age group. Judging from the mean-for-latitude norms, used in diagnostic studies in clinical examinations of patients, group 1 volunteers exhibited no normal values for the majority of metabolites. The greatest shifts from medical reference values were detected for plasma TCS concentration. The lowest concentration of TCS for children aged 2-14 years is 3.74 mmol/liter, for adults 3.9 mmol/liter [5]. The levels in the students in our study in September, November, February, March, and particularly in May were lower. Plasma TCS content in students varied from 2.60 to 4.21 mmol/liter throughout the year, while in group 2 its level was 4.55-6.42 mmol/liter. Blood concentrations of albumin and lactate were above the normal in many cases in both groups. These facts indicate that not only age-specific, but also regional clinical reference values for diagnostic studies should be corrected.

The study of the seasonal dynamics of metabolism parameters showed that in November, when air temperature dropped to negative values and the daylight duration decreased significantly, the main metabolic changes in both groups manifested by a reduction of glycemic level and accumulation of lactate to the values beyond the physiological norms. This is in line with the data of a 2-year study of carbohydrate metabolism in residents of the North [8] and attests to not metabolism disorders, but to more significant role of anaerobic glycolysis in the mechanism of energy homeostasis maintenance. Similar pattern of metabolic adaptation in both groups manifested irrespective of significant differences in nutrition: higher consumption in the older age group (by 14% above the normal) in parallel with lower (10%) carbohydrate nutrition and low consumption of all macronutrients (proteins, fats,

TABLE 1. Dynamics of Metabolite Concentrations in the Blood of Residents of the North of Different Age Groups throughout a Year

Group, month	Air temperature, C°	Glucose, mmol/liter	Lactate, mmol/liter	TGC, mmol/liter	TCS, mmol/liter	Albumin, g/liter
Reference values		3.9-5.6	0.5-2.2	0.15-1.82	before 5.7	35-50
18-20 years						
September (*n*=11)	12	4.79±0.22*	1.61±0.33*	0.61±0.09	3.28±0.14*	51.4±2.2*
November (*n*=9)	-8	3.88±0.44**	2.99±0.21**	0.57±0.13	3.39±0.24	54.0±1.6
December (*n*=11)	-8	4.36±0.26	3.6±0.13*	0.71±0.13	3.97±0.29	44.4±2.3**
February (*n*=15)	-9	4.56±0.17	2.88±0.17**	1.10±0.09*	3.44±0.25	45.9±2.8
March (*n*=8)	-6	5.32±0.14**	1.37±0.11***	0.58±0.09***	3.48±0.15	53.9±0.9***
April (*n*=11)	-1	4.53±0.11*	1.85±0.04***	0.53±0.08	4.21±0.26*	57.4±0.9*
May (*n*=10)	6	3.94±0.17**	1.77±0.21	0.69±0.16	2.60±0.17***	44.2±2.5***
June (*n*=7)	23	5.49±0.24***	2.54±0.22*	0.90±0.14	3.91±0.24***	62.2±4.5**
30-59 years						
September (*n*=14)	6	4.91±0.22	2.47±0.15	0.81±0.13*	4.86±0.37	55.5±1.6
November (*n*=17)	-8	3.71±0.24	2.83±0.08*	1.15±0.17	5.1±0.3	53.1±0.4
December (*n*=8)	-6	5.08±0.19**	2.04±0.14***	1.70±0.10*	5.32±0.35	45.1±2.4**
February (*n*=10)	-13	4.86±0.19	1.64±0.2	1.25±0.18*	6.42±0.28*	53.8±1.3**
March (*n*=14)	-6	4.74±0.19	2.52±0.16**	0.97±0.11	5.19±0.39*	51.4±1.8
April (*n*=12)	-6	4.78±0.13	2.75±0.23	1.14±0.19	5.64±0.26	58.8±2.9*
May (*n*=13)	6	4.67±0.14	1.97±0.14*	1.27±0.20	5.56±0.30	47.6±1.8**
June (*n*=13)	11	4.76±0.21	2.17±0.20	1.48±0.23	5.70±0.30	56.1±1.4**

Note. *$p<0.05$, **$p<0.01$, ***$p<0.001$ compared to the previous month.

carbohydrates, by 16, 20, and 26%, respectively) in group 1.

The metabolic parameters in the older age group (optimal level of nutrition) normalized in December (glucose concentration increased by 37%, lactate reduced by 28%). In the younger group, consumption of macronutrients was above the normal (proteins, fats, carbohydrates by 19, 32, 19%, respectively); lactat-acidosis was even more pronounced, though a trend to an increase of the glycemic level was noted; in other words, seasonal restructuring of metabolism was longer in young people. We think that metabolic adaptation during the first half of the cold season is aimed at lipid reservation. This hypothesis is in line with more than 2-fold increase in TGC concentration from September to December in older volunteers, similarly as in young subjects in whom this process is delayed: the concentration of TGC increases gradually, from November to February. The increase of the subcutaneous fat thickness confirms the predominating reservation (but not oxidation) of lipids during the fall-winter period [13].

Intensification of lipolysis was observed in both groups in March, despite significant differences in nutrition (the highest level of fat consumption in group 1 was 59% higher than the lowest threshold normal level, *vs.* normal level in group 2). Blood levels of TGC decreased by 47 and 22% compared to the previous month in groups 1 and 2, respectively. Lipolysis progressed in group 1 in April, which was seen from continuing reduction of the blood concentration of TGC and accumulation of albumin (above the normal), binding fatty acids released in TGC hydrolysis and functioning as their carrier [10]. Presumably, the maximum concentration of TCS, detected in April in group 1 and in February in group 2 and resulting from its increased synthesis from acetyl coenzyme A, forming in rather high amounts during intense degradation of fatty acids, confirms activation of lipolysis.

Replacement of the cold weather for warm and significant prolongation of the daylight hours were associated with metabolic changes of the same direction in the two groups, though of different intensity. In May, the increase of TGC concentration in young people was paralleled by a significant reduction of glucose, TCS, and albumin levels; in older subjects, lactate level decreased. In June, the content of all the studied metabolites increased, more so in group 1 (significantly for all values except TGC).

Hence, blood concentrations of glucose, lactate, and albumin vary greater in young people, while the levels of TGC and TCS are less variable than in older subjects. A greater range of fluctuations in comparison with the norm was detected for albumin and lactate concentrations in both groups. Despite age-specific characteristics of metabolism, common regularities were detected in the seasonal dynamics of metabolite concentrations in residents of the North from both groups. This common feature is greater contribution of anaerobic glycolysis to the maintenance of energy homeostasis at stage 1 of the cold period (fall-winter) and an increase of lipolysis at stage 2 (winter-spring).

The study was supported by the Russian Foundation for Basic Research (grant No. 04-06-00383a).

REFERENCES

1. A. P. Avtsyn, A. A. Zhavoronkov, A. G. Marachev, and A. P. Milovanov, *Human Pathology in the North* [in Russian], Moscow (1985).
2. N. A. Agadzhanyan and N. V. Ermakova, *Ecological Portrait of Man in the North* [in Russian], Moscow (1997).
3. E. R. Boiko, *Fiziol. Chel.*, **22**, No. 4, 122-129 (1996).
4. E. R. Boiko, *Physiological and Biochemical Bases of Human Vital Activity in the North* [in Russian], Ekaterinburg (2005).
5. L. A. Danilova, *Blood and Urine Analyses* [in Russian], St. Petersburg (1999).
6. N. R. Deryapa and I. F. Ryabinin, *Adaptation of Humans in Polar Regions of the Earth* [in Russian], Leningrad (1977).
7. V. P. Kaznacheev, V. Yu. Kulikov, and L. E. Panin, *Mechanisms of Human Adaptation under Conditions of High Latitudes* [in Russian], Leningrad (1980), pp. 10-24.
8. T. I. Kochan, *Ekol. Chel.*, No. 10, 3-7 (2006).
9. A. N. Martinchik, A. K. Baturin, V. S. Baeva, *et al.*, *Album of Foodstuff Portions and Dishes* [in Russian], Moscow (1995).
10. L. E. Panin, *Energy Aspects of Adaptation* [in Russian], Leningrad (1978).
11. V. N. Titov, *Klin. Lab. Diagnost.*, No. 4, 3-10 (1999).
12. A. V. Tkachev, E. R. Boiko, Z. D. Gubkina, *et al.*, *The Endocrine System and Metabolism in Man in the North* [in Russian], Syktyvkar (1992).
13. T. I. Kochan, *Environment and Human Health*, St. Petersburg (2003), pp. 780-781.
14. T. M. Makinen, T. Paakkonen, L. A. Palinkas, *et al.*, *Comp. Biochem. Physiol. A Mol. Integr. Physiol.*, **139**, No. 2, 229-238 (2004).
15. A. M. Van Ooijen, W. D. Van Marken Lichtenbelt, A. A. Van Steenhoven, and K. R. Westerterp, *Physiol. Behav.*, **82**, No. 2, 543-553 (2004).