Coll. Antropol. 39 (2015) 4: 887–892
Original scientific paper

Adaptive Changes in Basal Metabolic Rate in Humans in Different Eco-Geographical Areas

Arkady L. Maximov[1], Victor Sh. Belkin[2], Leonid Kalichman and Eugene D. Kobyliansky[2]

[1] International Scientific Center »Arktika« FEB RAS, Magadan, Russia
[2] Tel-Aviv University, Sackler Faculty of Medicine,Department of Anatomy and Anthropology, Tel-Aviv, Israel
[3] University of the Negev, Faculty of Health Sciences at Ben-Gurion, Recanati School for Community Health Professions, Physical Therapy Department, Beer-Sheva, Israel

ABSTRACT

Our aim was to establish whether the human basal metabolic rate (BMR) shifts towards the reduction of vital functions as an adaptation response to extreme environmental conditions. Data was collected in arid and Extreme North zones. The arid zone samples included Bedouins living in the Sinai Peninsula in Egypt, Turkmen students, the Pedagogical University of Chardzhou, Turkmenistan born Russians and Russian soldiers. Soldiers were divided into 3 groups according to the length of their tour of duty in the area: 1st group: up to six months, 2nd group: up to 2 years and the 3rd group: 3-5 years. The Extreme North samples comprised Chukchi natives, 1st generation Russian immigrants born in the area and 3 groups of soldiers comparable to the soldiers from Turkmenistan. BMR values of the new recruits had the highest values of total and relative BMR (1769±16 and 28.3±0.6, correspondingly). The total and relative BMR tended to decrease within a longer adaptation period. The BMR values of officers who served >3 years in Turkmenistan were very similar to the Turkmenistan born Russians (1730±14 vs. 1726±18 and 26.5±0.6 vs. 27.3±0.7, correspondingly). Similarly, in Chukotka, the highest relative BMR was found in the new recruits, serving up to 6 months (28.1±0.7) and was significantly ($p<0.05$) lower in the Russians serving in Chukotka over 1.5 years (27.1±0.3). The BMR was virtually similar in Russian officers serving >3 years, compared to the middle-aged Chukchi or Chukotka-born Russians (25.8±0.5 vs. 25.6±0.5 and 25.5±0.6, correspondingly). The BMR parameters demonstrated a stronger association with body weight than with age. In extreme environmental conditions, migrant populations showed a decrease in BMR, thus reducing its vital functions. The BMR reduction effect with the adequate adaptive transformation is likely to be the key strategy for developing programs to facilitate human and animal adaptation to extreme factors. This process is aimed at preserving the optimum energy balance and homeostasis while minimizing stress on the body's vital functions.

Key words: *adaptation, basal metabolism, Bedouins, Turkmens, Chukchi*

Introduction

The dynamics of changes in the basal metabolic rate (BMR), an indicator of metabolic transformations in the process of adaptation to extreme conditions, remains a controversial issue in anthropologic and physiological literature. It is one of the foremost topics in numerous studies investigating the changes of BMR values in humans and animals in hot and cold climates, at high altitudes and under other unusual environmental conditions[1-8]. In contrast, studies, particularly human studies, have shown that extreme high and low temperatures (with other conditions being comparable) may result in both enhanced and reduced basal metabolism in the process of adaptation[8-10].

It should be noted that in animal studies, there is no ambiguity. Pastukhov[11] demonstrated that adequate adaptive transformations aimed at optimization of body functions in severe climatic conditions of the Extreme North evolve towards reducing energy expenditures and BMR. BMR may continue to decrease up to hibernation both in hot and cold climates, and due to a combination of extreme factors. Definite conclusions in animal studies were attained due to the standardization in laboratory experiments and in studies conducted in natural life conditions.

Investigating human populations is more complex since it is very complicated to perform a simultaneous, strictly standard BMR monitoring in groups that are heterogeneous in age and gender structure; have undergone

Received for publication October 15, 2015

TABLE 1
SYNOPSIS OF THE STUDIED POPULATION

Studied population	Group number	Sample size	Age±SD (years)
Arid zone			
Young Bedouins	1	11	19.1±0.1
Middle-aged Bedouins	2	61	36.2±0.6
Turkmen (young males)	3	34	20.2±0.3
Russians-Turkmenistan-born (young males)	4	54	21.3±0.5
Military personnel serving in Turkmenistan for up to half a year (Russians)	5	39	18.8±0.1
Military personnel serving in Turkmenistan for over a 1.5 years (Russians)	6	47	19.5±0.3
Military personnel serving in Turkmenistan for over 3 years (Russians)	7	22	33.3±0.7
Extreme North			
Chukchis in Chukotka (young males)	8	37	20.7±0.9
Middle-aged Chukchis in Chukotka	9	28	32.5±0.6
Chukotka-born Russians (young males)	10	32	20.5±0.4
Military personnel serving in Chukotka for up to half a year (Russians)	11	14	18.6±0.1
Military personnel serving in Chukotka for over a 1.5 years (Russians)	12	27	20.1±0.3
Military personnel serving in Chukotka for over 3 years (Russians)	13	17	33.1±0.4

various adaptation stages and live in different extreme conditions with different nutrition levels and life cycles.

Modern scientific literature has coined the concept of »adaptive reduction in BMR«[12-16] dealing with the issues of over- and undernourishment and is therefore related to adaptive thermogenesis. Researchers conducting numerous studies in diverse natural habitats were unable to determine to what extent adequate adaptive transformations were related to the reduction/increase of vital signs.

Being aware of the complex nature of the problem, we attempted to integrate scientific data collected over 15 years of field research and establish whether the human BMR shifts towards the reduction of vital functions as an adaptation response to extreme environmental conditions.

Methods

Subjects

The arid zone population comprised Bedouins native to the Sinai Peninsula, students learning at the Teachers' Training College, Chardzhou (ethnic Turkmen), Turkmenistan-born Russians and military personnel serving different lengths of tour duty. Sample populations of Extreme North inhabitants included Chukchi natives, 1st generation Russians living in Chukotka and military personnel serving in the Providensky border guard detachment. A description of the studied groups is presented in Table 1 and Figure 1.

The studied Bedouin population belonged to the Muzeina tribe of the South Sinai that totals about 3,000 people. Previous studies have shown that habitat conditions, such as topographic isolation, high inbreeding level, lack of social stratification, limited food resources, lack of health care, a seminomadic lifestyle and an absence of urbanization, concurrently with the severe conditions of a hot climate in semi-deserts of the arid zone, affect anthropometric and morpho-functional features of the body[17-22].

The anthropometric and morpho-functional studies were conducted in Sinai by the staff of the Department of Anatomy and Anthropology, Sackler Faculty of Medicine, Tel-Aviv University, Israel and in Turkmenistan and on the Chukotka Peninsula by the staff of the Arctic International Research Center (the Far Eastern Branch of the Russian Academy of Sciences). The results of previously published Bedouin studies have been presented at various scientific forums[23-25].

The arid zone study included 268 men subdivided into age groups: Bedouins aged 18-20 (19.1±0.1) – 11 subjects

Fig. 1. Study area map.

and Bedouins aged 31-40 (36.2±0.6) – 61 subjects. The similar age groups of the studied Turkmenistan and Chukotka inhabitants furnished a basis for a comparative analysis (Table 1).

Among the participating students of the Chardzhou College, ethnic Turkmen aged 17-21 (20.2±0.3) accounted for 34 subjects and Turkmenistan-born Russians aged 18-23 (21.3± 0.5) – 54 subjects.

Military personnel drafted mainly from European and Northern-Ural regions of Russia, totaled 108 subjects and were subdivided into three groups: new recruits, tour of duty in Turkmenistan <6 months (39 people, aged 18.8±0.1); 1.5-2 years of service (47 subjects, aged 19.5±0.3), and a tour of duty of 3-5 years (22 subjects, aged 33.3±0.7).

One hundred and fifty-five subjects participated in the Chukotka study of the Extreme North. The native population consisted of young male Chukchi students from technical and vocational schools living in the settlements of Providenye, Lavrenty and Whalen (37 young males, aged 17-24 (20.7±0.9)). Reindeer herdsmen, technical workshop workers, craftsmen and unskilled workers (28 people, aged 25–35 (32.5±0.6)) comprised the middle-aged sample. The first-generation Extreme Northern born participants were mostly ethnic Russians and Ukrainians (32 subjects, aged 19-22 (20.5±0.4)).

In order to evaluate the course of adaptation processes, the military personnel were subdivided into three groups: tour of duty of up to a half a year; 1.5 to 2 years and 3 to 5 years. Fourteen subjects, aged 18.6±0.1, comprised the new recruit group with a tour of duty under half a year; a tour of duty between 18 and 36 months – 27 subjects, aged 20.1±0.3; a tour of duty of 3-5 years – 17 subjects, aged 28-35 (33.1±0.4). The servicemen had had no experience of living under the harsh conditions of the North and were drafted to serve in Chukotka from central regions of Russia, the Transcaucasian region and Central Asia.

BMR evaluation

All studies were conducted in March and/or April between 6am and 7am local time, in a room with a controlled temperature of 20-22 °C. The recruitment was voluntary and in compliance with the medical and biological code of ethics. Under the field conditions of Sinai, BMR was measured by indirect calorimetry using the Benedict-Roth Metabolism Apparatus (Warren E Collins, Inc).

A Spirolit type gas analyzer was used in some of the Chukotka studies, while in other studies, a Holden analyzer was used. These two types of gas analyzers provided comparable readings of oxygen consumption and exhaled carbon dioxide levels, thus providing the basis for calculating the daily BMR.

In all evaluations, the following information was collected: 1) standard demographic data, 2) food consumption during the last 24 hours, 3) smoking habits and 4) health history. To reduce the stress level before each evaluation, subjects were instructed as to the involved procedure and practiced breathing with a mouthpiece and nose clip. Using the Spirolit-2 analyzer, oxygen consumption and exhaled carbon dioxide levels (in ml/min) were identified. BMR was estimated using a respiratory coefficient (the ratio of exhaled carbon dioxide to oxygen consumption levels).

In addition to the total BMR value, its relative (BMR/body weight) value was also calculated. We did not provide data on the expected BMR values, as these were irrelevant to the issue of increased or reduced metabolism at the adaptation stages. Since all studies were performed under field conditions in a makeshift space, the researchers made their best effort to comply with the mandatory methodological requirements for basal metabolism studies.

Statistical analysis

All results are expressed as mean ± standard error (SE). The analyses included descriptive statistics, correla-

TABLE 2
BASAL METABOLISM AND BODY WEIGHT OF THE ARID ZONE INHABITANTS

Studied group	Group number	Traits (M±m)			
		Age (years)	Body weight (kg)	Total BMR (kcal/day)	BMR/body weight, (kcal/kg)
Young Bedouins	1	19.1±0.1	53.5±0.9	1571±15	29.6±0.4
Middle-aged Bedouins	2	36.2±0.6	61.4±1.5	1660±23	27.0±0.6
Turkmen (young males)	3	20.2±0.3	62.9±0.7	1715±30	27.2±0.5
Turkmenistan-born Russians (young males)	4	21.3±0.5	63.2±0.6	1726±18	27.3±0.7
Military personnel serving in Turkmenistan for up to half a year (Russians)	5	18.8±0.1	62.5±0.8	1769±16	28.3±0.6
Military personnel serving in Turkmenistan for over a 1.5 years (Russians)	6	19.5±0.3	64.3±0.9	1734±25	26.9±0.4
Military personnel serving in Turkmenistan for over 3 years (Russians)	7	33.3±0.7	67.8±1.1	1730±14	26.5±0.6

TABLE 3
BASAL METABOLISM AND BODY WEIGHT OF THE EXTREME NORTH INHABITANTS

Studied group	Group number	Traits (M±m)			
		Age (years)	Body weight (kg)	Total BMR (kcal/day)	BMR/body weight (kcal/kg)
Chukchis in Chukotka (young males)	8	20.7±0.9	64.7±0.6	1731±28	26.7±0.4
Middle-aged Chukchis in Chukotka	9	32.5±0.6	68.3±0.8	1750±33	25.6±0.5
Chukotka-born Russians (young males)	10	20.5±0.4	67.9±1.2	1735±30	25.5±0.6
Military personnel serving in Chukotka for up to half a year (Russians)	11	18.6±0.1	63.4±0.4	1779±37	28.1±0.7
Military personnel serving in Chukotka for over 1.5 years (Russians)	12	20.1±0.3	64.7±0.5	1754±31	27.1±0.3
Military personnel serving in Chukotka for over 3 years (Russians)	13	33.1±0.4	67.6±1.0	1747±32	25.8±0.5

tion analysis, breakdown and one-way analysis of variance (ANOVA). Posteriori multiple comparisons of means were applied by the Tukey Honest Significant Difference (HSD) test. The p-values indicated the post hoc significance levels for the respective pairs of mean values. A p-value ≤ 0.05 was considered statistically significant. The aforementioned calculations were performed using the STATISTICA package (StatSoft Inc.).

Results and Discussion

Arid zone

Table 2 shows the total and relative BMR values in the studied groups. Among individuals living in the hot arid climate, young Bedouin males (group 1) were found to have the lowest BMR value. The maximum BMR value, 1769±16 kcal per day, was observed amongst the servicemen during their first half-year in Turkmenistan. Numerous studies[26-28] have shown that individuals who do not adapt to the environment experience a higher level of stress and higher BMR.

In our study, BMR values of the new recruits confirmed this assumption, as they had the highest values of total and relative BMR (1769±16 and 28.3±0.6, correspondingly). With a longer adaptation period (longer tour of duty in a specific area), the total and relative BMR tended to decrease. The BMR values of officers with tours of duty longer than three years in Turkmenistan were very similar to the values of the Turkmenistan born Russians (1730±14 *vs.* 1726±18, and 26.5±0.6 *vs.* 27.3±0.7, correspondingly).

A higher total BMR in middle-aged Bedouins compared to the younger males may appear abnormal, taking into account that they are in their prime, have a higher social ranking in the tribe, receive better nutrition and are probably less exposed to stress and extreme factors. However, the relative BMR in this group was 27.0±0.6 kcal/kg, whereas in the young Bedouins (group 1), it was 29.6 kcal/kg ($p<0.05$), indicating a higher metabolism in the young Bedouin males.

Environmental-wise, we found similar values of the relative BMR in natives of the arid zone irrespective of their habitat (for comparable body weight). Thus, for Bedouins and Turkmen with a body weight of 61-63 kg, the variance of relative BMR did not exceed 2%, remaining within the margin of measurement error.

The analysis of servicemen adapting to the hot climate clearly shows the BMR tendency to decrease with time spent in the arid zone, confirming the results of previous studies conducted in the region from1950-1980[29-33]. A decrease in BMR was observed even in individuals with a higher body weight and a much longer period of adaptation (group 7). Still the relative BMR, which indirectly reflects metabolism intensity was 12% less in group 7 (25.5±0.5 kcal/kg) than the values for the new recruits (28.3±0.6 kcal/kg) with a tour of duty in Turkmenistan of up to 6 months.

Extreme north

The analysis of BMR values for the individuals residing in Chukotka (groups 8-13) showed a similar pattern of relative BMR association with length of adaptation period (Table 3). The highest relative BMR was found in new (up to six month in the area) recruits (28.1±0.7) and significantly ($p<0.05$) lower in Russians serving in Chukotka over a period of 1.5 years (27.1±0.3). The relative BMR of Russian officers serving >3 years was virtually similar to the middle-aged Chukchis or Chukotka born Russians (25.8±0.5 *vs.* 25.6±0.5 and 25.5±0.6, correspondingly).

We found that Turkmenistan and Chukotka natives (groups 3 and 8) were not significantly different in their average age, body weight and total or relative BMR (Figures 2, 3). Turkmenistan and Chukotka born Russians (groups 4 and 10, correspondingly) were also similar in age, however, the relative BMR of group 10 was 6% lower

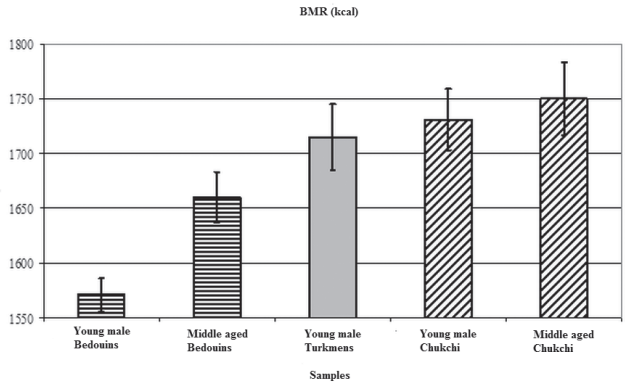

Fig. 2. Total BMR in native inhabitants of the arid zone and the Extreme North.

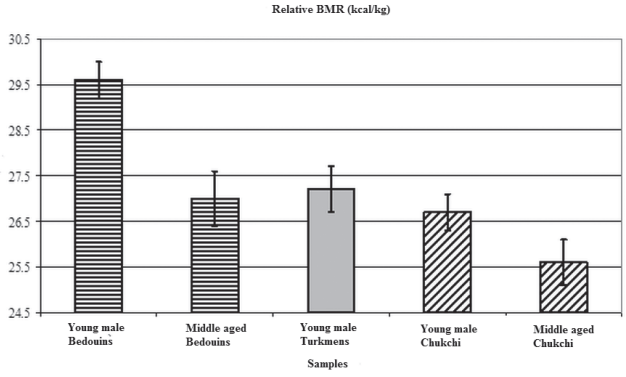

Fig. 3. Relative BMR in native inhabitants of the arid zone and the Extreme North.

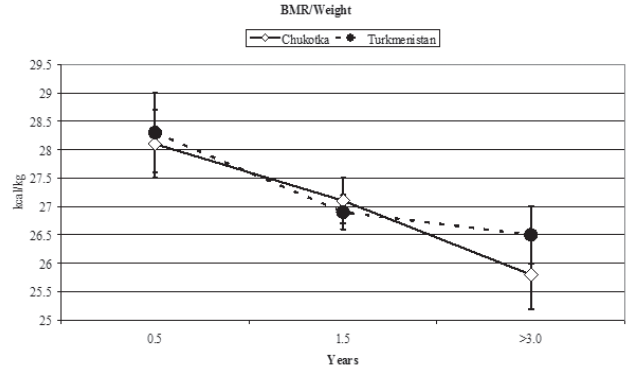

Fig. 4. Dynamics of the relative BMR in servicemen in Turkmenistan and Chukotka. Dotted line – servicemen in Turkmenistan; solid line – servicemen in Chukotka.

than that of group 4 ($p<0.05$). This finding is in accord with our assumption that the adaptive transformation of the organism in response to extreme climate is the reduction of basal metabolism.

These dynamics of BMR changes is distinct in migrants exposed to harsh environmental conditions for the first time. Figure 4 illustrates the dynamics of the relative BMR in the military personnel from Turkmenistan and Chukotka. The highest values were observed during the first half-year following the arrival of the participants to their region of military service. Later, relative BMR values showed a tendency to decrease in both, arid and in Extreme Northern zones; however, there were no significant differences between the BMR values of the Turkmenistan and Chukotka servicemen with similar tours of duty.

The BMR parameters indicated a stronger association with body weight than with age. Comparing the values of groups 2, 3 and 4 (population groups that can be regarded as best-adapted to their living conditions and whose body weight is comparable), no significant differences in their BMR values was observed. A similar pattern was noted in groups 9 and 10.

The Pearson correlation analysis determined the association between age, body weight and BMR. In the Turkmenistan inhabitants, the correlation between BMR and age was $r=0.23$ and for BMR and body weight, $r=0.48$ ($p<0.05$ in all computations). In the Bedouin population, these correlations were lower, – 0.11 and 0.33, respectively. For the Chukchis, the correlation between age and BMR was 0.17 and between the body weight and BMR, – 0.51. For the resident migrant populations, it was 0.25 and 0.66, correspondingly ($p<0.05$ in all computations). Consequently, the BMR was found to have a stronger association with body weight than age. This conclusion is only valid for the studied populations (females, children and the elderly may display other interrelations).

Conclusions

Studies performed in various natural and climatic regions indicate that in harsh environmental conditions, a migrant population shows a decrease in the basal level of energy expenditure, tending towards a reduction of its vital functions.

We found that native populations continuously exposed to extreme environmental factors exhibit the lowest possible level of basal metabolism that may not correspond to the optimal values typical of individuals under more favorable (comfortable) living conditions.

The BMR reduction effect with adequate adaptive transformations is likely to be the key strategy for developing programs to facilitate human and animal adaptation to extreme factors. This process is aimed at preserving optimum energy balance and homeostasis while minimizing the stress on the body's vital functions.

Acknowledgements

The authors thank Mrs. Phyllis Curchack Kornspan for her editorial services.

REFERENCES

1. BAKER PT, The Biology of High-Altitude Peoples. (Cambridge University Press, 1978). — 2. VORONIN NM, The basics of medical and biological climatology. (Medicina, Moscow, 1981). — 3. LAVIE S, YOUNG WC, Antipode, 16 (1984) 33. — 4. ULIJASZEK SJ, Am J Hum Biol, 8 (1996) 169. — 5. KOZLOV AI, VERSHUBSKY G, KOZLOVA M, Int J Circumpolar Health, 62 (2003) 158. — 6. KOZLOV AI, VERSHUBSKY G, KOZLOVA M, Int J Circumpol Heal, S1 (2007). — 7. LEAR SA, TOMA M, BIRMINGHAM CL, FROHLICH JJ, Metabolism, 52 (2003) 1295. — 8. SNODGRASS JJ, LEONARD WR, TARSKAIA LA, ALEKSEEV VP, KRIVOSHAPKIN VG, Am J Hum Biol, 17 (2005) 155. — 9. BARBARASH NA, DVURECHENSKAYA GY, Physiology of adaptation processes (Nauka, Moscow, 1986). — 10. CEPON TJ, SNODGRASS JJ, LEONARD WR, TARSKAIA LA, KLIMOVA TM, FEDOROVA VI, BALTAKHINOVA ME, KRIVOSHAPKIN VG, Am J Hum Biol, 23 (2011) 703. — 11. PASTUKHOV YF, MAXIMOV AL, KHASKIN VV, Adaptation to cold and Subarctic conditions: the problems of thermo-physiology, (NESC FEB RA, Magadan, 2003). — 12. DULLOO AG, JACQUET J, Am J Clin Nutr 68 (1998) 599-606. — 13. DULLOO AG, JACQUET J, MONTANI JP, SCHUTZ Y, Obes Rev 13, S2 (2012) 105. — 14. ROSENBAUM M, LEIBEL RL, Int J Obes (Lond), 34 (2010) S47. — 15. SIMPSON A, MAYNARD V, Int J Circumpolar Heal, 71 (2012) 1. — 16. WECK M, BORNSTEIN SR, BARTHEL A, BLUHER M, Dtsch Med Wochenschr, 137 (2012) 2223. — 17. SCHOFIELD WN, Hum Nutr Clin Nutr, 39 (1985) S5. — 18. JAMES WP, Hum Nutr Clin Nutr, 39 (1985) S92. — 19. DE BOER JO, VAN ES AJ, VOORRIPS LE, BLOKSTRA F, VOGT JE, Eur J Clin Nutr, 42 (1988) 983. — 20. HENRY CK, REES DG, Eur J Clin Nutr, 45 (1991) 177. — 21. RODE A, SHEPHARD RJ, Am J Hum Biol, 7 (1995) 723. — 22. LEONARD WR, SORENSEN MV, GALLOWAY VA, SPENCER GJ, MOSHER MJ, OSIPOVA L, SPITSYN VA, Am J Hum Biol, 14 (2002) 609. — 23. ARENSBURG B, HERSHKOVITZ I, KOBYLIANSKY E, MICLE S, Bulletins et Mémoires de la Société d'anthropologie de Paris, 6 (1979) 363. — 24. KOBYLIANSKY E, HERSHKOVITZ I, Biology of Desert Populations – South Sinai Bedouins: Growth and Development of Children in Human Isolates. (ERAUL 82, Liege, 1997) 282. — 25. BELKIN V, CHUMAKOVA A, KOBYLIANSKY E, Bulletin of Moscow University Series XXIII Anthropology, (2012) 87. — 26. PANIN LE, USENKO GA, Anxiety, adaptation and prenosological dispensary system (SO RAMN,Novosibirsk, 2004). — 27. SHETTY PS, HENRY CJ, BLACK AE, PRENTICE AM, Eur J Clin Nutr, 50 (1996) S11. — 28. HORGAN GW, STUBBS J, Eur J Clin Nutr, 57 (2003) 335. — 29. SLONIM AD, Foundation of General Mammals Ecological Physiology (Academic Press, Moscow-Leningrad, 1961). — 30. SLONIM AD, On the physiological mechanisms of natural adaptation of humans and animals (Nauka, Moscow-Leningrad, 1964). — 31. BABAEV AB, CHARYEV M, GLEZER GA, Kardiologiia, 23 (1983) 76. — 32. BABAEV AH, SULTANOV FF, SERYABRYAKOV EP, Issues and other physiological mechanisms of adaptation to the hot climate (Ylim, Ashgabat, 1970). — 33. BAGIROV BG, Man and hot climate (Ylim, Ashgabat, 1977) 189

E. Kobyliansky

Tel-Aviv University, Sackler Faculty of Medicine, Department of Anatomy and Anthropology, Ramat-Aviv, 69978 Tel Aviv, Israel
e-mail: anatom14@post.tan.ac.il

ADAPTIVNE PROMJENE BAZALNOG METABOLIZMA KOD LJUDI U RAZLIČITIM EKO-ZEMLJOPISNIM PODRUČJIMA

SAŽETAK

Naš cilj je bio utvrditi da li se stope ljudskog bazalnog metabolizma (BMR) pomiče prema smanjenju vitalnih funkcija kao adaptacija i odgovor na ekstremne uvjete okoliša. Podaci su prikupljeni u suhim i ekstremnim zonama na Sjeveru. Uzorci iz suhih područja uključuju beduine koji žive na Sinajskom poluotoku u Egiptu, turkmenistanske studente, Pedagoško Sveučilište Chardzhou, Turkmenistace rođene u Rusiji i ruske vojnike. Vojnici su bili podijeljeni u 3 skupine prema dužini njihove ture dužnosti u području: 1. skupina: do šest mjeseci, 2. skupina: do 2 godine i 3. skupine: 3–5 godina. Ekstremni uzorci sa Sjevera se sastoje od Chukchi domorocima, prve generacije ruskih imigranata rođene u tom području i 3. skupine vojnika usporedive s vojnicima iz Turkmenistana. BMR vrijednosti novih regruta su imale najviše vrijednosti ukupnog i relativnog BMR-a (1769 ± 16 i 28,3 ± 0,6, odgovarajući). Ukupni i relativni BMR su skloni smanjenju u roku dužeg razdoblja prilagodbe. BMR vrijednosti časnika koji su služili više od 3 godine u Turkmenistanu su bili vrlo slični Turkmenistancima rođenima u Rusiji (1730 ± 14 vs. 1726 ± 18 i 26,5 ± 0,6 vs. 27,3 ± 0,7, odgovarajući). Slično tome, u Chukotki, najveći relativni BMR je pronađen kod novaka koji su služili do 6 mjeseci (28,1 ± 0,7) i bio je značajno ($p<0,05$) niži u Rusa koji služe u Chukotki u duljini od 1,5 godina (27,1 ± 0,3). BMR je gotovo sličan kod ruskih časnika koji su služili više od 3 godine, u odnosu na sredovječne Chukchije ili Rusi rođene u Chukotki (25,8 ± 0,5 vs. 25,6 ± 0,5 i 25,5 ± 0,6, odgovarajući). BMR parametri su pokazali snažniju povezanost s tjelesnom težinom nego s dobi. U ekstremnim uvjetima, populacija migranata pokazala je smanjenje BMR-a, čime su se smanjile njihove vitalne funkcije. Učinak BMR-a je redukcija s odgovarajućom adaptivnom transformacijom je vjerojatno da će biti ključna strategija za razvoj programa koji će olakšati ljudima i životinjama prilagodbu ekstremnim uvjetima. Ovaj proces je usmjeren na očuvanje optimalne energetske ravnoteže i homeostaze, a umanjuje stres na tijelo vitalnih funkcija.