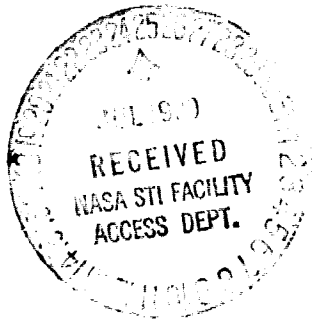
NASA TECHNICAL MEMORANDUM

NASA TM-76114

EFFECT OF SHARPLY LOWERED MUSCULAR ACTIVITY ON THE THYROID GLAND OF THE WHITE RAT

K. Bekishev

Translation of "O vliyanii na shchitovidnuyu zhelezu belykh krys rezko snizhennoy myshechnoy deyatel'nosti," Izvestiya Akademii Nauk Kazakhskoy SSR, Seriya Biologicheskaya, No. 2, Mar-Apr 1978, pp 75-78



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546 APRIL 1980

EFFECT OF SHARPLY LOWERED MUSCULAR ACTIVITY ON THE THYROID GLAND OF THE WHITE RAT

K. Bekishev

Up to the present time there has been totally inadequate study of the effect /75* of hypokinesia on the endocrine apparatus and in particular on the thyroid gland, a most important organ that regulates basic metabolism in the organism. The literature throws light on only single pieces of research having to do with the animal thyroid under hypokinetic conditions. Unfortunately, however, these works pay no attention to the micrometric character of morphofunctional thyroid units, the follicles, and especially to the height of follicular epithelium which is the only reliable criterion for proper appraisal of the level of thyroid functional activity based on a histological study.

In our study of 200 mongrel male white mice with an initial weight of mostly 170-190 g attention was paid chiefly to micrometric data -- height of the follicular epithelium and interior diameter of the follicules, as well as to the condition of colloid, the most adequate of the morphological signs that characterize the functional activity of the thyroid gland [1, 2, 3]. According to A. A. Voytkevich [3], changes in the average height of the thyroid's follicular epithelium that amount to 1 micron on the whole are evidence of an important shift in the functional activity of this organ. I. P. Pushkarev [4] in fact established a high correlation between the average height of the thyroid's follicular epithelium and functional assessment of the thyroid using labeled iodine.

A sharp reduction in muscular activity — hypokinesia -- was induced by placing the rats in very narrow cages 16 cm long by 6 cm wide. It was very difficult for the rats to change their position.

10 rats were selected for each time period and an equal number of controls. The latter were kept in the same room and sacrificed at the same time intervals as the experimental animals. All animals were weighed before the experiment began and again

---

*Numbers in the margin indicate pagination in the foreign text.

TABLE 1. CHANGE IN BODY MASS AND MASS OF MUSCULUS GASTROCNEMIUS IN HYPOKINESIA AND DURING RECOVERY

A Группа крыс	B Срок убоя от начала опытов, сут	C Масса крысы, г		F Масса икроножных мышц, г	
		D перед началом опыта	E при убое	G абсолютная	H относительная на 100 г массы тела
1 Гипокинезия	1	170	170	1,37	0,806
	3	—	—	1,39	0,818
	5	—	—	1,43	0,841
	7	—	—	1,48	0,871
	10	—	—	1,49	0,876
2 Контроль к ним	5	—	179	1,34	0,743
1 Гипокинезия	15	180	180	1,53	0,849
	30	180	191	1,55	0,813
	60	180	194	1,74	0,895
	90	180	217	1,89	0,874
2 Контроль к ним	15	180	202	1,53	0,756
	30	180	220	2,07	0,943
	60	180	230	2,11	0,916
	90	180	250	2,18	0,852
3 Обратимость после 15-суточной гипокинезии	30	160	208	1,62	0,770
2 Контроль к ним	30	160	200	1,56	0,783
4 Обратимость после 30-суточной гипокинезии	30	164	230	2,03	0,813
2 Контроль к ним	30	164	228	1,86	0,834
5 Обратимость после 90-суточной гипокинезии	15	180	248	1,79	0,722
2 Контроль к ним	15	180	260	1,91	0,735
6 Обратимость после 90-суточной гипокинезии	30	180	288	2,07	0,719
2 Контроль к ним	30	180	270	2,01	0,744

Key:
A. Group of rats.
B. Duration of experiment before sacrifice (days).
C. Mass of rats (g).
D. Before experiment.
E. At the time of sacrifice.
F. Mass of calf muscles (g).
G. Absolute.
H. Relative per 100 g of body weight.
1. Hypokinesia.
2. Control.
3. Reversibility after 15-day hypokinesia.
4. Same after 30-day hypokinesia.
5. Same after 90-day hypokinesia.
6. Same after 90-day hypokinesia.

at the time of sacrifice. Following sacrifice both lobes of the thyroid gland were exstirpated and weighed together on a torsion balance. The same procedure was followed with the calf muscles. On the basis of rat mass and the relative mass (per 100 g body mass) of the calf muscles an assessment was made of the effect of experimental conditions on the animal organism and its muscular system.

The thyroid glands were fixed in Bouin's fluid, dipped in paraffin and microtomed.

TABLE 2. CHANGE IN THYROID MASS, HEIGHT OF FOLLICULAR EPITHELIUM AND FOLLICLE DIAMETER IN HYPOKINESIA AND AFTER RECOVERY

A Группа крыс	B Сроки убоя от начала опытов, сут	Масса щитовидной железы, г C		F Высота фолликулярного эпителия, мкм	G Диаметр фолликулов, мкм
		D абсолютная	E относительная на 100 г массы тела		
1 Гипокинезия	1	15,7	9,23	8,7±0,15	46,8±1,3
	3	16,0	9,41	8,8±0,07	47,2±1,0
	5	15,1	8,88	8,8±0,06	49,0±1,3
	7	17,6	10,35	8,9±0,1	49,6±1,4
	10	18,4	10,82	9,3±0,1	44,9±0,7
2 Контроль к ним	5	18,0	10,05	8,0±0,07	58,4±1,2
3 Гипокинезия	15	20,2	11,22	10,65±0,28	41,6±1,8
	30	17,7	9,27	9,5±0,2	49,0±1,3
	60	17,8	9,18	8,35±0,05	57,7±1,4
	90	18,1	8,87	7,95±0,1	59,4±1,3
2 Контроль к ним	15	18,5	9,16	7,6±0,08	73,8±1,5
	30	19,4	8,82	8,5±0,06	61,1±1,7
	60	23,0	10,00	8,2±0,1	62,9±1,6
	90	21,6	9,84	8,2±0,2	61,6±1,6
4 Обратимость после 15-суточной гипокинезии	30	19,3	9,28	8,5±0,08	51,8±0,6
2 Контроль к ним	30	19,0	9,50	8,3±0,07	53,3±0,6
5 Обратимость после 30-суточной гипокинезии	30	20,0	8,69	8,5±0,06	52,5±0,5
2 Контроль к ним	30	19,2	8,61	8,4±0,09	52,6±0,7
6 Обратимость после 90-суточной гипокинезии	15	17,5	7,06	8,1±0,1	56,7±1,5
2 Контроль к ним	15	19,0	7,31	8,4±0,09	53,2±0,6
7 Обратимость после 90-суточной гипокинезии	30	21,2	7,37	8,6±0,07	51,4±0,5
2 Контроль к ним	30	20,0	7,41	8,4±0,07	52,9±1,7

Key:
A. Group of rats.
B. Duration of experiment before sacrifice (days).
C. Mass of thyroid gland (g).
D. Absolute.
E. Relative per 100 g body weight.
F. Height of follicular epithelium (microns)
G. Follicle diameter (microns).
1. Hypokinesia.
2. Control.
3. Hypokinesia.
4. Reversibility after 15-day hypokinesia.
5. Same after 30-day hypokinesia.
6. Same after 90-day hypokinesia.
7. Same after 90-day hypokinesia.

Section width was 6 microns. They were stained with hematoxylin-eosin and enclosed in Canadian balsam. In addition to the routine histological study of the preparations there was also a filar micrometer measurement of the inside diameter of 100 follicles and the height of thyrocytes in their epithelial pavement. The averaged data were treated by variation statistics.

The hypokinesia experiments showed that the rat mass does not change the first

15 days but thereafter lags far behind the control in this respect (Table 1). Beginning at the 1 month mark the calf muscles likewise lag in respect to mass (relative mass is less indicative since the experimental rats have not grown as fast as the controls). From the 1 month point they also lag in respect to thyroid gland mass except for the first 15 days, when the absolute and relative mass of the thyroid is much higher than in the control. During this time, if we are to judge by the condition of the colloid (its fluidity and the abundance of resorptive vacuoles) and especially by micrometric data, the thyroid gland is in a condition of maximal excitation: the height of the follicular epithelium is at its peak and follicle diameter at its lowest (10.65±0.28 and 41.6±1.8 microns, Table 2). /76

However, we note intensification of thyroid functional activity once the animal has spent 24 hours in a narrow cage, when the difference in values for the height of follicular epithelium (8.7±0.15 compared with 8.0±0.07 microns in the control) and follicle diameter (46.8±1.3 compared with 58.4±1.2 microns in the control) is very reliable ($P < 0.001$).

At the 1 month point the group average showed a height in follicular epithelium that was 1 micron more and a follicle diameter that was 10 microns less than for the control. However, in 3 out of 10 rats the thyroid functional condition, judging by the histological data, had already returned to normal and by day 60 the thyroid of all rats showed no differences from that of the controls.

V. V. Portugalov and co-authors [5, 6], working with laboratory mice and mongrel white rats placed in box-cages, described an initial phase of maximal tension in the thyroid gland. For the rats this lasted 1-5 days. Thyroid functional activity returned to normal in the case of the mice after 1 month and in the rats by days 45-60 of their stay in the box-cages. /77

We did not study the thyroid condition of rats following 1.5 months of hypokinesia but we were also convinced that its functioning returned to normal in all the animals by day 60. In our experiments the first phase was more extended; apparently intensification of thyroid functioning is explained by other experimental conditions. Tight cages are not the same as synthetic glass containers and in our experiments motor activity was less reduced, especially during the first month, when the rats were able to change position in these tight cages more freely. As they got

heavier it became harder to change position. However we noticed the same rule at work as did V. V. Portugalov et al.

In order to study and explain the degree of reversibility of white rat thyroid changes induced by hypokinesia we set up three series of experiments: at the end of a month following 15- (1) and 30-day (2) periods spent by the rats in narrow cages (in ordinary cages during the periods of peak thyroid activity induced by hypokine- /78 sia); at the end of 15 and 30 days (3) following a 3 month stay in narrow cages. 5 rats were involved each time in the experiments with 90-day hypokinesia and 5 controls, in the other cases 10 (see Tables 1 and 2). A comparison of the data in the Tables shows, that a month after the replacement of hypokinetic conditions by normal ones the experimental rats, whose weight had lagged behind that of the controls, to a significant degree (3-7%) overtook the latter in this respect. The relative mass of the calf muscles and thyroid gland in the experimental rats were back to normal a month after the beginning of the recovery period and this was also true of the micrometric indices for the degree of thyroid functional activity: there was no statistically reliable difference in these values between experimental rats and controls.

We have not found any analogous studies in the literature.

On the basis of the materials presented we may draw these conclusions:

1) Taking as criterion the height of the follicular epithelium and the condition of the colloid, white rats present a reliable increase in thyroid functional activity already after 24 hours hypokinesia and this activity grows considerably stronger by day 10 of their stay in conditions that sharply curtail muscular activity, attaining a maximum 15 days after the animals began to live under conditions that prevent mobility;

2) The functional condition of the thyroid in rats that have spent 30 days under such conditions returns to normal in one third of the animals and after day 60 in all experimental rats.

3) Rats that have spent 15, 30 or 90 days in very confining cages and have consequently lagged behind their controls in weight, to a certain extent overtake them

a month after being returned to ordinary cages.

4) After a month's recovery period rats that have spent 15, 30 and 90 days in hypokinesia present thyroid conditions that are the same as those of the control; therefore the changes induced in the thyroid gland by a sharp reduction in motor activity are already reversible at the end of a month.

REFERENCES

1. Aleshin, B. V., Razvitiye zoba i patogenez zobnoy bolezni [Development of Goiter and Pathogenesis of the Disease], Kiev, 1954.

2. idem, Shchitovidnaya zheleza v kn. Bol'shaya meditsinskaya entsiklopediya [The Thyroid Gland in the Great Medical Encyclopedia], Moscow, 1964, 2nd ed.

3. Voytkevich, A. A., Antitireoidnoye deystviye sul'fanilamidov i tioreatov [Antithyroid Effect of Sulfanilamdes and Thyroates], Moscow, 1957.

4. Pushkarev, I. P., Morfofunktsional'naya kharakteristika shchitovidnoy zhelezy sviney iz rayonov Yugo-Zapadnogo Uzbekistana [Morphofunctional Characteristics of the Thyroid Gland in Swine from the Southwestern Regions of Uzbekistan], Author's abstract of candidate's dissertation, Samarkand-Dushanbe, 1971.

5. Poetugalov, V. V. et al., O nekotorykh effektakh, voznikayushchikh pri gipokinezii (opyty na myshchakh) v kn. Kosmicheskaya biologiya i meditsina [Some Effects Appearing in Hypokinesia (Mouse Experiments) in Space Biology and Medicine], Moscow, 1967, Vol. 1.

6. idem et al., K voprosu ob izmeneniyakh v nekotorykh endokrinnykh zhelezakh i sekretiruyushchikh yadrakh gipotalamusa pri gipokinezii v kn. Trudy konferentsii "Eksperiment, issledovaniya gipokinezii, izmenennoy gazovoy sredy, uskoreniya, peregruzok i drugikh faktorov" [Changes in Some Endocrine Glands and Secretory Nuclei of the Hypothalamus in Hypokinesia in Transactions of the Conference on Experiment and Research regarding Hypokinesia, Modified Gas Environment, Acceleration, Overloads and Other Factors], Moscow, 1968, pp 29-33.