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Translation of "Rost i formirovaniye skeleta peredney konechnosti u inbrednykh myshey i krys v usloviyakh gipo, normo- i giperdinamikik",

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16. Abstract

Inbred 1 month old males of C57B 1/6. CBA. CC57Br/Mw interlinear hybrid mice of the first generation and rats of the August and Wistar lines were subjected to conditions of hypo, normo- and hyperdynamia for 2 months. The statistically reliable dependence is shown between mechanical underloadings and overloadings and macro microscopic changes in the hind limb skeleton of animals. Genetic determination of growth and formation of the forelimb skeleton is established. Hereditary susceptibility and the phenomenon of heterosis are preserved under all motor conditions.

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GROWTH AND FORMATION OF THE FORELEG SKELETON IN INBRED MICE AND RATS UNDER CONDITIONS OF HYPO-, NORMAL AND HYPERDYNAMIA

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Inbred 1 month old males of C57B 1/6. CBA. CC57Br/Mw interlinear hybrid mice of the first generation and rats of the August and Wistar lines were subjected to conditions of hypo, normo-and hyperdynamia for 2 months. The statistically reliable dependence is shown between mechanical underloadings and overloadings and macro microscopic changes in the hind limb skeleton of animals. Genetic determination of growth and formation of the fore-limb skeleton is established. Hereditary susceptibility and the phenomenon of heterosis are preserved under all motor conditions.

The growth in the skeleton of the foreleg of rodents under conditions /67* of limited mobility has been studied by L. I. Avdyunichev (1965) and Riesenfeld (1966). However their experiments are incomplete since they are linked to the amputation of one of the extremities, or extirpation of muscles and denervation of the latter which results in disruption in the functions of the organism as a whole as a result of surgical intervention. Especial attention should be given to the works in which studies are made of the consequences of immobilization of the extremity by application of plaster, or limitation in the mobility of the animal by placing it in a small-sized cage (Seireg

*Numbers in margin indicate pagination in original foreign text.

et al., 1969; Mateef et al., 1971, 1971 a, 1972; Jankovich, 1972). Their essence is reduced to the fact that the hypofunction limits the growth of bones, alters their structure and results in atrophy of the bone tissue. Experimental data on the effect of the hyperfunction on the growth of the bones of the foreleg are fairly contradictory (Chernyy, 1950; Bunak, Klebanova, 1960; Donaldson et al., 1935; Mateef et al., 1971, 1971 a, 1972). The optimal and ultraoptimal loads, in our opinion, play a morphogenetic role. The studies made on the inbred, or so-called line rodents who have undergone many brother-sister interbreedings and have reached a high level of homogeneity, with a certain genotype inherent to each line prove the genetic programming of the growth and structure of the skeleton (Cruneberg, 1957, 1958; Deol et al., 1957, 1958; Stein, 1957). Therefore it is logical to assume that the same load has a different effect on the growth and formation of the skeleton with regard to the individual-genetic peculiarities of the organism.

Experiments were conducted on mice in the line C57Bl/6, CBA, CC57Br/Nv, hybrids of the first generation F_1 and rats in the lines August and Wistar (only one-year-old males). Thirty mice and 45 rats of each line were taken which were divided into three groups of 10 mice and 15 rats in each. For the first group of animals conditions of hypodynamia were created by placing them in box cages of small size. The second group of animals were maintained under normal conditions of a vivarium (conditions of normal dynamics). For the third group of animals conditions of hyperdynamia were created by training them to run on a track designed by us. The training of this group of animals started with a 3-minute run, daily increasing its duration by 1 minute. At the end of the experiment we had reached 60 minutes. For animals of all groups and lines a standard food ration was observed. The experiment lasted two months and encompassed a period of intensive growth of the animals. The animals were killed by injection with a needle into the medulla oblongata, after which the bones of the fore left extremities were macerated by chemical means in 1.5% solution of potassium alkali at temperature 45°. The macerated bones were studied according to Duerst (1926).

The program of osteometry included study of the scapulae and humeral bones with determination of their weight, greatest length and width (in the humerus in the widest place of diaphysis, proximal and distal epiphysis). /68
All the numerical materials were processed by the method of variation statistics with the use of the tables of N. N. Samoylov (1970) on the computer "Mir."

Osteometry of the scapulae and humeral bones of the experimental animals revealed a direct dependence of weight, longitudinal and transverse dimension on the conditions of maintenance of the animals. Analysis of the statistically reliable data indicated that with a transition of hypodynamia to normal and hyperdynamia the weight of the studied bones (table 1) increased in the animals of all lines. One should note that under conditions of limited mobility the weight of the bones was altered considerably greater than under conditions of increased muscle activity. This is governed, evidently, by osteoporosis that developed in the bones of the animals under conditions of hypodynamia (Bykov, Novikova, Ivanova, 1970; Delling et al., 1970; Mateyev et al., 1970; Nikityuk, 1971; Mach, 1971). The growth of the scapulae and humeral bones in length was delayed in the hypodynamic and stimulated in the hyperdynamic animals of all lines (figure 1). It was estab- /69 lished that analogous statistically reliable changes are observed also in the transverse growth of the studied bones of the animals in limits of hypo, normal and hyperdynamic groups (table 2).

TABLE 1. WEIGHT OF BONES OF FORELEG (mg) IN ANIMALS OF DIFFERENT LINES DEPENDING ON DYNAMIC PATTERN*

Animal	Hypodynamia		Normal Dynamia		Hyperdynamia	
	Scapulae	Humeral Bone	Scapulae	Humeral Bone	Scapulae	Humeral Bone
Mice						
C57Bl/6	6,3±0,2	7,9±0,2	13,8±0,3	20,1±0,3	16,7±0,3	25,1±0,3
CBA	8,4±0,2	12,6±0,3	15,1±0,3	22,4±0,2	18,5±0,2	26,0±0,2
CC57B/Mv	10,0±0,2	15,1±0,2	18,2±0,3	26,1±0,2	20,1±0,2	27,3±0,2
F_1	14,1±0,3	23,0±0,2	22,6±0,3	27,8±0,3	25,4±0,3	30,9±0,2
Rats						
August	39,3±0,9	101,6±0,9	62,5±0,6	129,9±0,5	72,1±0,6	136,6±0,5
Wistar	43,6±0,5	117,7±0,4	68,5±0,5	139,7±0,8	83,9±0,7	149,0±0,8

*The intralinear and interlinear difference in all cases is reliable.

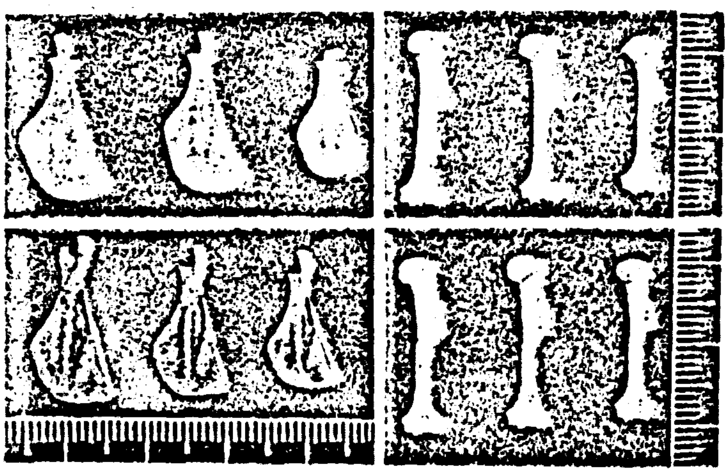

Figure 1. Scapulae and Humeral Bones of Inbred Rats Under Hypo-, Normal- and Hyperdynamia (From Right to Left):
Upper line--animals in August line; lower line--Wistar lines

TABLE 2. MEASUREMENTS OF BONES IN FORELEG SKELETON (mm) IN ANIMALS OF DIFFERENT LINES DEPENDING ON DYNAMIC PATTERN*

Animal	Hypodynamia		Normal Dynamia		Hyperdynamia	
	Width of Scapulae	Width of Diaphysis of Humeral Bone	Width of Scapulae	Width of Diaphysis of Humeral Bone	Width of Scapulae	Width of Diaphysis of Humeral Bone
Mice						
C57Bl/6	6,05±0.08	[illegible]2±0.01	6,86±0,04	1,14±0,01	7,22±0,02	1,30±0,02
CBA	7,15±0,04	1,12±0,02	7,31±0,02	1,21±0,02	7,49±0,02	1,41±0,02
CC57Br/Mv	7,46±0,011	1,35±0.02	7,61±0,01	1,41±0,02	7,78±0,03	1,64±0,02
F_1	7,92±0,02	1,46±0,03	8,02±0,03	1,54±0,01	8,15±0,04	1,78±0,02
Rats						
August	11,09±0,05	2,97±0,01	11,93±0,03	2,21±0,02	12,32±0,01	2,35±0,01
Wistar	12,01±0,02	2,27±0,01	12,37±0,01	2,38±0,01	12,62±0,01	2,51±0,01

*Intralinear and interlinear difference in all cases is reliable

At the same time one should stress that all the longitudinal and transverse dimensions of the flat and tubular bones of the fore extremities of the growing animals of different lines under conditions of hypo-, normal and hyperdynamia reach their genetically predetermined limit, which is indicated by the reliable interlinear differences of these signs (figure 2, 3). Taking into consideration the homogeneity in the groups of hypo-, normal and hyperdynamic animals that we studied we are justified in explaining the /70
presence of interlinear variability of these indices due to the genotype predisposition of the linear animals to the mechanical loads and underloads. According to all the osteometric indices the hybrids of the first generation F_1 exceed their parental forms of the linear mice CBA and C57Bl/6, which indicates the manifestation of the phenomenon of heterosis in all the studied motor patterns.

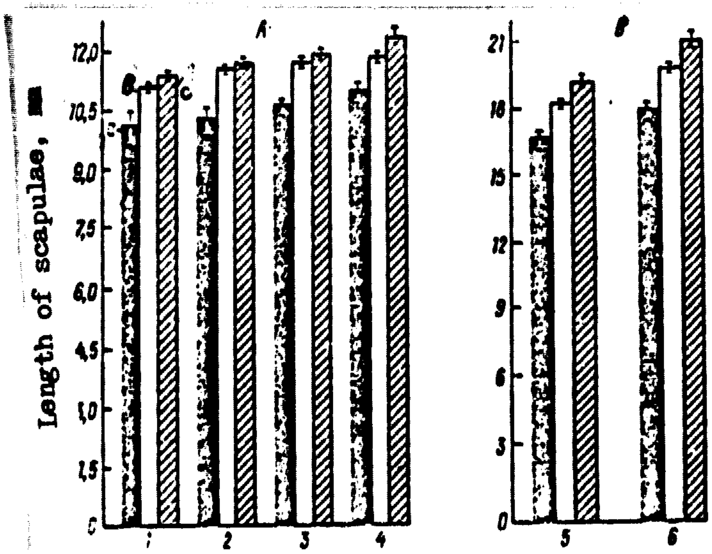

Figure 2. Length of Scapulae in Inbred Animals of Different Lines

Key:
1. Mice C57Bl/6
2. Mice CBA
3. Mice CC57Br/Mv
4. Mice F_1
5. Rat August
6. Rat Wistar

a. Hypodynamia
b. Normal dynamia
c. Hyperdynamia

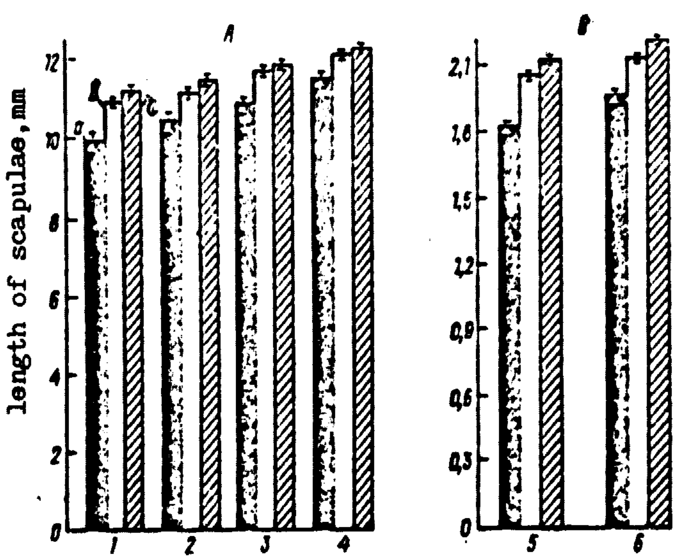

Figure 3. Length of Humeral Bone in Inbred Animals of Different Lines

Key:
1. Mice C57Bl/6
2. Mice CBA
3. Mice F_1
4. Mice CC57Br/Mv
5. Rat August
6. Rat Wistar

a. Hypodynamia
b. Normal dynamia
c. Hyperdynamia

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