NASA TECHNICAL TRANSLATION NASA TT F-15,511

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N74-20721

(NASA-TT-F-15511) THE EFFECT OF HYPODYNAMIA AND HYPOKINESIS ON THE ARTERIAL TREE OF THE PELVIC MUSCLES OF THE RABBIT'S EXTREMITIES (Techtran Corp.) 9 p HC $4.00 CSCL 06C G3/04 Unclas 36291

Translation of "Vliyaniye Gipodinamii i Gipokinezii na Arterial'noye Ruslo Myshts Tazovoy Konechnosti Krolika," Arkhiv Anatomii Gistologii i Embriologii, Vol. 67, No. 4, April 1972, pp. 48-52.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546 MAY 1974

STANDARD TITLE PAGE

1. Report No. NASA TT F-15,511	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle THE EFFECT OF HYPODYNAMIA AND HYPOKINESIS ON THE ARTERIAL TREE OF THE PELVIC MUSCLES OF THE RABBIT'S EXTREMITIES		5. Report Date May 1974
		6. Performing Organization Code
7. Author(s) N. Ye. Sokolov		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address Techtran Corporation P.O. Box 729, Glen Burnie, Md. 21061		11. Contract or Grant No. NASw-2485
		13. Type of Report and Period Covered Translation
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D. C. 20546		
		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of "Vliyaniye Gipodinamii i Gipokinezii na Arterial'noye Ruslo Myshts Tazovoy Konechnosti Krolika," Arkhiv Anatomii Gistologii i Embriologii, Vol. 67, No. 4, April 1972, pp. 48-52.

16. Abstract

Effects of hypodynamic conditions on the arterial bed in the muscles and adjacent structures of pelvic extremities in the rabbit was the subject of the investigation. Anatomical methods of investigation revealed, that hypodynamic conditions produced morphological transformations in intraorganic arterial system in the muscles, fascia and adipose cellular tissue of the immobilized extremity. These changes proved to be stable and retained during 6 months.

17. Key Words (Selected by Author(s))	18. Distribution Statement Unclassified-Unlimited		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 9	22. Price 4.00

NASA-HQ

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THE EFFECT OF HYPODYNAMIA AND HYPOKINESIS ON THE ARTERIAL TREE OF THE PELVIC MUSCLES OF THE RABBIT'S EXTREMITIES

N. Ye. Sokolov[1]

Today the study of the effect of hypodynamia and hypokinesis on the cardiovascular system is of great interest for space biology and medicine. /48*

Investigations of the vascular system under conditions of hypodynamia and hypokinesis are primarily conducted in the physiological and biochemical aspects. Morphological investigations conducted in this field are significantly fewer in number (V. A. Odinokova, 1952; O. V. Nedrigaylova, 1956; Albertazzi, 1955). It is pointed out in these studies that significant morphological changes occur in the wall of the blood vessels of the muscles of the extremities /49 under conditions of hypokinesis; these changes are expressed in increased growth of connective tissue of the inner lining of the blood vessels, exhaustion of the vascular walls, and decrease in the size of the lumen up to complete obliteration, as well as in a decrease in the number of small blood vessels and capillaries.

Reports of an anatomical character on the condition of the vascular tree of various organs under conditions of hypodynamia and hypokinesis have been presented in several studies carried out by associates of the Chair of Normal Anatomy of the First Leningrad Medical Institute, supervised by meritorious scientific activist Professor M. G. Prives (L. A. Aleksina, 1968; M. G. Prives, 1970; A. V. Drozdova, 1970). We did not encounter any studies devoted to studying the effect of hypokinesis on the arterial channel of the muscles in the available literature.

The goal of this investigation was to reveal morphological changes in the arterial tree of the pelvic muscles of the rabbit's extremities under conditions of partial hypodynamia and hypokinesis.

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

29 rabbits served as the experimental material; of this number 8 were control animals and were used to study the normal morphological picture of the arterial system of the pelvic muscles of the extremities. In order to create partial hypodynamia and hypokinesis, a circular plaster cast was placed on the right pelvic extremity of the test rabbits. During this process the extremity was forced into the flexure position with the ankle, knee and hip joints bent. The plaster cast in the form of a band surrounded the caudal portion of the trunk together with the bound extremity. The condition of the arterial tree of the muscles of the pelvic region of the extremities was studied over various periods of time (ranging from 1 week to 6 months) while the extremity was kept under conditions of immobilization.

The method of the investigation consisted in injecting the Gaukh x-ray contrast medium into the arterial tree using the modification of M. G. Prives and of x-raying the entire extremity, as well as each muscle individually. Injections of a contrast-gelatin mass with subsequent preparation of sections of the muscles and their illumination in the A. M. Malygin method were used as well as injections of latex and preparations of the blood vessels by passing them through reflected light under the MBS-2 binocular magnifier.

A study of the preparations of the muscles of the control animals demonstrated that the intraorganic arterial network consists of arteries of I-IV or V orders of branching and capillaries. All of the intramuscular arteries visible in the illuminated preparations can be divided into three groups: large, with a diameter ranging from 80-60 μ, medium — 60-40 μ, and small — 40-7 μ. The secondary branches of these blood vessels form a large number of anastomoses, while the capillary networks are distributed uniformly throughout the entire muscular cavity, forming angular loops winding among the muscular fibers (Figure 1). The arteries which emerge in the surface fascia have a longitudinal direction with respect to the extremity. Subsequent branching occurs as the result of alteration of the transverse and longitudinal directions of arteries of the II-IV or V orders of branching and capillaries, which, anastomosing with each other, form a network consisting of various loops which vary with respect to size and direction (Figure 2). In the fascia itself, the vascular networks are located in several layers. The arterial net of the subcutaneous lipid tissue consists of small loops located quite close to each other, as the result of which it appears very dense. The loops of the net have a predominantly circular shape without determinable orientation (Figure 3). In the norm all of the intra-organic arteries of the muscles and formations surrounding them have clearly defined even outlines and a straight course. The diameter of the main blood vessels uniformly decreases proportional to their passage in a peripheral direction into their subsequent separation into daughter branches.

An investigation of the material obtained from the experimental animals demonstrated that under conditions of partial hypokinesis significant changes in the arterial tree of the muscles, fascia, and lipid tissue of the immobilized extremity occur. Even after 1-2 weeks of immobilization, an increase in the diameter of the arteries of all sizes (Figure 4) was observed. The arterial net became more dense as the result of an increase in the number of injected arteries of small size and of the anastomoses between them. The precapillaries and capillaries were found in greater numbers than among the control animals and were located near each other, as the result of which the capillary network acquired a small-loop character. All branches of the arterial tree were /50
uniformly filled with the injected mass and had even outlines along their course, as well as a straight passage. Along the course of the small arteries and capillaries, in places, coloring of muscular bundles with the injection mass was noted, a phenomenon apparently linked with an increase in permeability of the vascular walls which is characteristic for hypoxia (G. I. Mchedlishvili, 1958; L. A. Alekzina, 1968; A. V. Drozdova, 1970; Albertazzi, 1955; Ralmissano, 1959). In the arterial network of the subcutaneous lipid tissue (Figure 5) and in the surrounding muscles of the fascia, expansion of the diameter of the arteries and increase in the number of small blood vessels and capillaries was observed, as it was in the muscles, a situation which led to a noticeable increase in the thickness of the network of blood vessels of these formations with overall maintenance of the vascular picture.

Figure 1. Intraorganic Arteries of the Biceps Muscle of the Hip in the Norm. Injection contrast gelatin. Magnification 37.

Figure 2. Arteries of the Fascia Surface of the Lower Third of the Hip in the Norm. Injection contrast gelatin. Magnification 37.

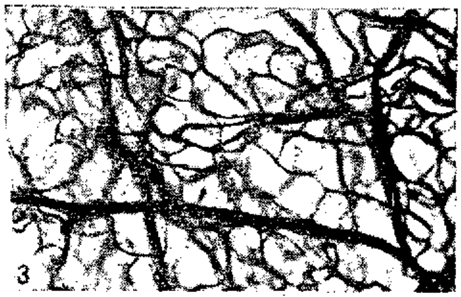

Figure 3. Arteries of the Subcutaneous Lipid Tissue of the Mid Third of the Hip in the Norm. Injection contrast gelatin. Magnification 37.

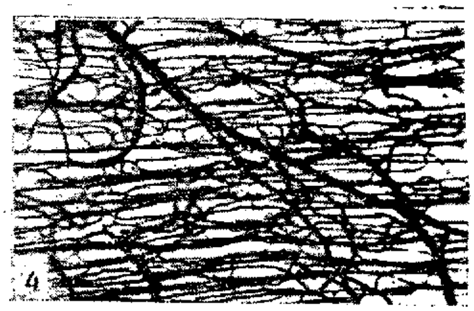

Figure 4. Intraorganic Arteries of the Biceps Muscle of the Hip One Week Following Immobilization. Injection contrast gelatin. Magnification 37.

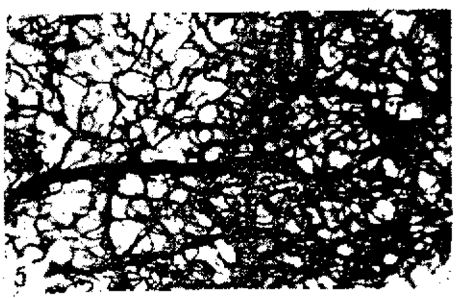

Figure 5. Arteries of the Subcutaneous Lipid Tissue of the Mid Third of the Hip Two Weeks Following Immobilization.

Figure 6. Intraorganic Arteries of the Muscles of the Hip a Month After Immobilization. Injection contrast gelatin. Magnification 37.

After 1 month of immobilization one observed subsequent expansion of the arteries, in comparison with the preceding periods, as well as an increase in their number and in the anastomoses between them (Figure 6). Additionally, the arteries of mid and small size and the anastomoses between them acquired uneven outlines and in places became convolutive. The injection mass also filled the veins which were also enlarged and had a twisting course and nonuniform diameter along their length. After 3 months all elements of the arterial channel of the muscles were significantly enlarged and had an uneven diameter over their course; they also became convoluted (Figure 7). The capillary net maintained its small loop structure but its component blood vessels were in places convoluted in a corkscrew shape. In almost all regions of the muscles one observed extrusion of the injection mass beyond the limits of the small blood vessels and capillaries, as a result of which certain small blood vessels had an unclearly defined mixed contour. After 6 months of immobilization the diameter of the muscular blood vessels noticeably decreased but their convoluted nature remained (Figure 8). The blood vessels formed flexures which increased the nonuniformity of the diameter of the arteries and veins of mid and large size and along the course of some of them one encountered spindle-like expansions. The small size blood vessels in places acquired corkscrew-like or spiraled shape. In the terminal region of the vascular tree one observed stenosis and emptying of a large portion of the precapillaries and capillaries, but in certain regions of the muscles they were paralytically expanded and had poorly defined outlines. In certain preparations it was impossible to trace the outline of the terminal blood vessels as the result of staining of the surrounding tissue with the contrast medium; here one encountered small extravasates. The observed changes led to total disruption of the angioarchitectonics of the muscles of the immobilized extremity. In the fascia surrounding the muscles (Figure 9) and the subcutaneous lipid tissue, the arteries had a twisted course in various types of expansion and bulging of the walls. The small blood vessels seemed to have been emptied and were traced in the form of shadows. Consequently, changes in the arterial tree of the muscles of the pelvic region of the extremities and the surrounding formations observed under conditions of partial hypodynamia and /52
hypokinesis are maintained and do not disappear over the course of 6 months.

Figure 7. Intraorganic Arteries of the Biceps Muscle of the Hip After Three Months of Immobilization. Injection contrast gelatin. Magnification 37.

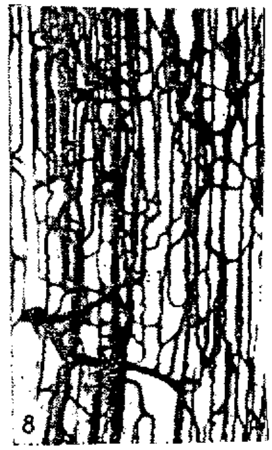

Figure 8. Capillary Net of the Biceps Muscle of the Hip After Six Months of Immobilization. Injection contrast gelatin. Magnification 37.

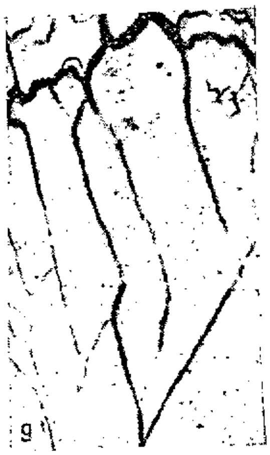

Figure 9. Arteries of the Surface Fascia of the Lower Third of the Hip After Six Months of Immobilization. Injection contrast gelatin. Magnification 37.

Hence, partial hypodynamia causes certain morphological changes in the arterial tree of the muscles of the immobilized extremity and in the formations surrounding the muscles. These changes are manifested in expansion of the arteries, convolutive course of the arteries, and uneven diameter (alteration of contract and expansion) along their course, extrusion of the injection mass beyond the limits of the blood vessel into the surrounding tissue, and in the late periods, one adds to this emptying of the precapillaries and capillaries. Such changes in blood vessels were observed during hypodynamia and hypokinesis (Yu. V. Latova, 1967; B. A. Dushkov, A. N. Zolotukhin, A. V. Korobkov, F. P. Kosmolinskiy, 1969; M. G. Prives, 1970; A. V. Drozdova, 1970) in the blood vessels of other organs. Destructive changes pertain only to the large blood vessels, but in the terminal part of the vascular tree, which is indicated in our experiments by emptying of the capillaries and precapillaries.

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Translated for the National Aeronautics and Space Administration under contract No. NASw-2485 by Techtran Corporation, P. O. Box 729, Glen Burnie, Maryland, 21061. Translator: Samuel D. Blalock, Jr.