Impact of Some Dietary Patterns on the Glandular System of the Large-Intestine Walls

M. R. Sapin and D. B. Nikityuk

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Dietary patterns influence the morphology of the digestive organs and the functional anatomy of the glandular system in the walls of internal organs, as has been established in animal experiments and discussed in the literature in the light of comparative theriological data. In carnivorous mammals the initial portion of the digestive tract is abundantly supplied with glands located within its walls [4]. Herbivorous animals, on the other hand, have a greatly enlarged stomach and, especially, an increased size of the large bowel, which consists of (several divisions [6]. As the size of this part of the digestive tract increases, so does the number of mucosal glands whose endocrine activity is essential for the digestion of carbohydrate- and fiber-rich foods. As has been found experimentally, force-feeding of rats with fiber-rich plant foods leads to greater numbers and size of the duodenal (Brunner's) glands, expansion of the area occupied by them in the duodenal walls, and enhanced secretory activity of these glands [9]. Experimental animal data are often extrapolated to modern man, though not always justifiably so: most mammals consume more specialized diets than do people today, who are omnivorous and whose ancestors were never exclusively carnivorous. Yet many of the structural features of the digestive tract demonstrated by theriologists and experimental biologists have been shown to be shared by man.

The objectives of this study were to compare large-intestine glands of persons who had been predominantly eating a vegetarian diet with the glands of those who had been consuming mainly mixed diets, and to adduce in this context pertinent experimental findings published in the literature.

Department of Human Anatomy, I. M. Sechenoff Moscow Medical Academy

MATERIALS AND METHODS

Glands of the large intestine were taken for study at autopsy from four adults with a proven long history (10 to 25 years) of eating predominantly vegetarian food and from 50 controls of comparable ages who had been mostly consuming mixed diets. The glands were examined by macroscopic/microscopic, macromorphological, and biometric methods.

RESULTS

Persons who had been mainly consuming foods of plant origin were found to have an increased (by 2.12% on average) total length of the cecum and colon and greater surface areas of the mucous membranes in these two parts of the large intestine as compared to individuals whose diets had mainly consisted of mixed foods (for convenience, individuals of these two groups are referred to below as vegetarians and nonvegetarians). These findings are consistent with the reported increased dimensions of mainly the proximal portions of the large bowel in herbivorous animals [5], which is explained by the role this part of the digestive tract plays as a reservoir for bacterial (enzymatic) degradation of cellulose and other forms of dietary

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fiber (fiber constitutes up to 45% of plant foods by weight [2]). A person who has been eating a vegetarian diet for a long time also has increased sizes of the other parts of the large intestine. According to Polyantsev [3], elongation of the sigmoid colon in habitual vegetarians is a beneficial phenomenon. Consideration of comparative morphological data shows that the increased sizes and volumes of the intestines in herbivores as compared to carnivores are due to the need for the former to consume low-calorie foods during most (3/4) of the day in order to meet their energy requirements.

The present study demonstrated a considerable development of the large-intestine glands in vegetarians. The total number of these glands in such individuals was greater by a factor of 1.29 than in nonvegetarians. The number of glands per mm^2 of intestinal wall was also higher (by a factor of 1.23) in the vegetarians. This suggests that prolonged consumption of plant foods promotes the formation of new glands in the large-intestine walls. The possibility of the formation of new intestinal glands during postnatal life has been shown in animal experiments. In rats, for example, the total number of glands between days 7 and 21 of life was found to increase from 1.9×10^6 to 3.3×10^6 in the small-intestine walls and from 2.2×10^5 to 6.5×10^5 in the large-intestine walls [12]. Wistar rats were reported to develop new intestinal glands at the age of 3-5 months [14]. In adult rats, new glands in the small-intestine walls arise both through branching and splitting of the existing glands and by lateral budding off from the latter [16].

In a vegetarian, about 150 g of dietary fiber is taken in every day [11], which is far more than in a person consuming a traditional mixed diet. The intestinal mucosa in vegetarians must therefore be protected by a powerful layer of mucus to prevent the intestinal wall from being damaged by roughage. Our study identified a morphological equivalent responsible for abundant mucus secretion by the large-intestine glands of vegetarians. Thus, the vegetarians' glands were, on average, inscreased 1.74 times in length ($p<0.001$) and 1.34 times in surface area ($p<0.001$) than the glands of nonvegetarians. Moreover, the number of epithelial cells forming a large-intestine gland in vegetarians was 1.11 times greater while the lumens of the excretory ducts of their glands were 1.34 times larger in area ($p<0.001$). The widening of the excretory gland lumens in vegetarians appears to be an adaptive response designed to facilitate the release of secretion onto the surface of the intestinal epithelial lining. In a broader biological context, such a modification of glandular ducts allows for the accumulation and concentration of the secreted product, this being a characteristic feature of exocrine glands in general [1].

Our data on the greater development of the large-intestinal glandular system in individuals eating predominantly plant foods are in agreement with experimental findings [9]. Animals consuming considerable amounts of fiber show increased proliferation of glandulocytes in the duodenal glands and intensified secretion of mucous products by these glands. In our study, longitudinal sections of intestinal glands from vegetarians each contained, on average, 4.3% more goblet cells, which are known to be active mucus secretors, than did sections of such glands from nonvegetarians. Examination of biopsy specimens taken in pigs from an area proximal to the ileocecal transition revealed sharply reduced secretion by small-bowel glands in animals that had not been receiving fiber in their diets [15]. In rats fed fiber-deficient diets, the proliferation of epithelial cells in the jejunal glands was greatly reduced and the transit time of contents via the jejunal lumen was increased as compared with the case in rats maintained on diets with adequate fiber [15].

The addition of foods high in fiber to the diet of persons suffering from chronic colitis or other disease and receiving adequate medical care has been shown to result in a rapid improvement of morphological and histochemical characteristics of the intestinal wall [10]. In the tropical and southern parts of Africa, where the population consumes foods high in fiber (cereals, root crops, legumes, etc.), the incidence of diseases affecting the large intestine, such as cancer, polyps, and hemorrhoids, is extremely low [11].

In considering the possible mechanisms through which the glandular system of the large intestine undergoes structural modification (resulting, for example, in increased sizes of the glands and in the number of cells in their walls), the contribution made to such modification by the intestinal microflora, in particular its secretory role, should also be appreciated [11]. Among the specific factors that presumably stimulate formative processes in the glandular apparatus, mention may be made of two enzymes stimulating tissue growth, namely ornithine decarboxylase and diamine oxidase [7].

REFERENCES

1. Yu. P. Kostilenko, *Arkh. Anat.*, **62**, № 5, 71-76 (1972).
2. E. I. Naumova, *Functional Morphology of the Digestive System in Rodentia and Lagomorpha* [in Russian], Moscow (1981).

3. A. A. Polyantsev, *Trudy Kazan. Med. Instituta*, **5**, 164-196 (1934).
4. R. D. Sinel'nikov, in: *Macroscopic and Microscopic Examinations of Glands, Mucous Membranes, and Skin* [in Russian], Moscow (1948), pp. 253-258.
5. M. S. Spirov, in: *Appendicitis* [in Russian], Kiev (1966), pp. 319-330.
6. S. F. Fillips, in: *Physiology and Pathophysiology of the Gastrointestinal Tract* [in Russian], Moscow (1989), pp. 340-355.
7. T. A. Sheshunova, *Usp. Sovr. Biol.*, **106**, № 2 (5), 306-318 (1988).
8. I. V. Shust, F. A. Zvershkhanivskii, Z. N. Shust, *et al.*, in: *Dietary Fiber in the Sensible Human Diet* [in Russian], Moscow (1989), pp. 151-154.
9. A. N. Yatskovskii and T. V. Boronikhina, *Byull. Eksp. Biol. Med.*, **103**, № 2, 208-209 (1987).
10. D. P. Barkitt, *Brit. Med. J.*, **1**, 274-278 (1973).
11. S. Bingham and J. H. Cummings, in: *Medical Aspects of Dietary Fiber*, New York (1980), pp. 261-284.
12. A. Maskens, *Acta Anat. (Basel)*, **9**, № 2, 231-240 (1978).
13. J. More, J. Fioramonti, F. Benazet, and L. Bueno, *Histochemistry*, **87**, № 2, 189-194 (1978).
14. W. H. St. Clair and J. W. Osborne, *Cell Tiss. Kinet.*, **18**, № 3, 255-262 (1985).
15. C. Tasman-Jones, R. L. Owen, and A. L. Jones, *Dig. Dis. Sci.*, **27**, № 2, 519-524 (1982).
16. S. Yonichi, Y. Nagashima, O. Yukio, *et al.*, *Anat. Anz.*, **159**, Nos. 1-5, 306-309 (1985).

METHODS

Adaptation of an ML-2 Microscope to *In Vivo* Experimental Studies of the Peripheral Circulation

L. S. Ivanov, K. N. Plotnikov, and A. G. Zakharov

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Russian industry has no experience in manufacturing special optic microscopes for *in vivo* studies on the laboratory animals. We modified an ML-2 microscope in order to solve some problems arising during studies of the peripheral circulation. The basic scheme of technical modification is presented in Fig. 1.

The microscope body is raised few centimeters with the aid of a metal plug (1). Taking into account peculiarities of illumination of the bioptate (the skeletal muscles or the intestinal mesentery), a condenser (2) is made of two hollow metal cylinders. During focusing, the inner cylinder can be manually moved up and down by rotation-translation movement along the helical slot in the outer cylinder and fixed in a definite position with the stop screw (3). A demountable metal housing (4) with the condenser optic unit is placed in the inner cylinder. The outer cylinder is inserted in the metal flange (5), fitted with three centered screws and fastened firmly to the microscope base. A metal housing with collector lens is stationary mounted on the flange. For light flux dosage an iris (6) with graduated aperture-setting limb is attached to the illuminator taken from an MBI-15 mi-

Institute of Physico – Technical Problems, Russian Academy of Sciences, Moscow. (Presented by D. S. Sarkisov, Member of the Russian Academy of Medical Sciences)

