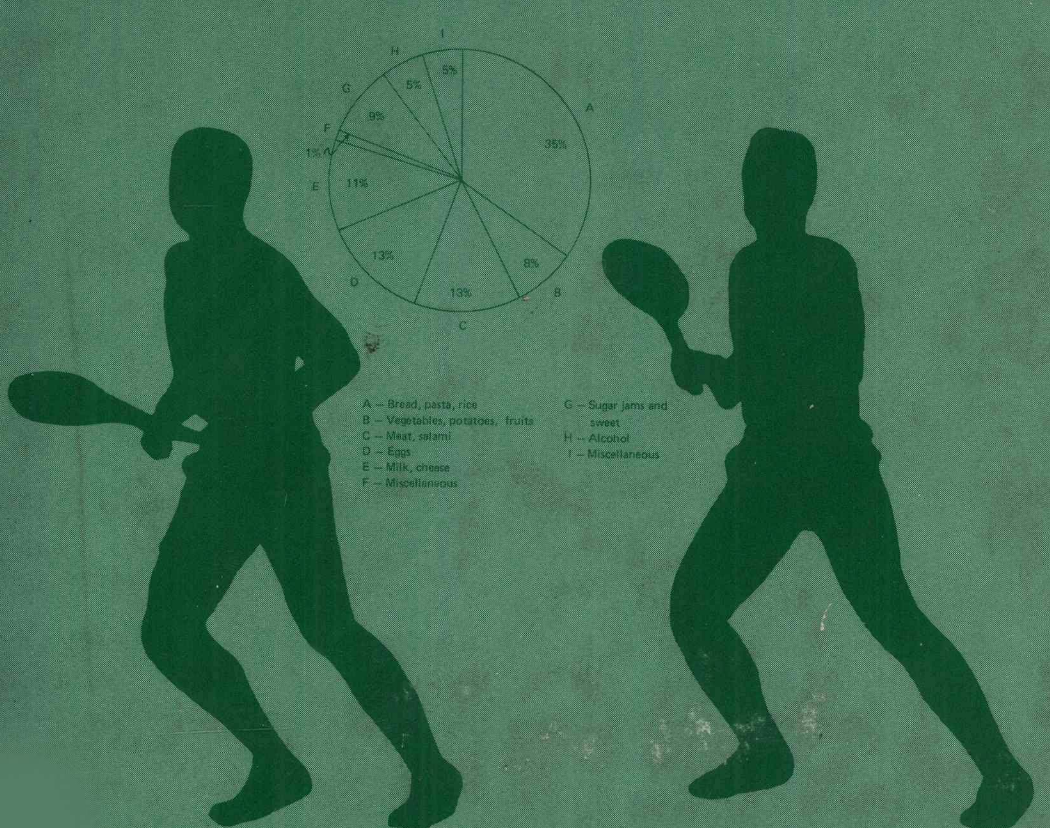
International Series on Sport Sciences
Volume 7

NUTRITION, PHYSICAL FITNESS, AND HEALTH

Edited by
Jana Pařízková and V. A. Rogozkin



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International Series on Sport Sciences

Series Editors: **Richard C. Nelson and Chauncey A. Morehouse**

The principal focus of this series is on reference works primarily from international congress and symposium proceedings. These should be of particular interest to researchers, clinicians, students, physical educators, and coaches involved in the growing field of sport science. The Series Editors are Professors Richard C. Nelson and Chauncey A. Morehouse of The Pennsylvania State University. The series includes the eight major divisions of sport science: biomechanics, history, medicine, pedagogy, philosophy, physiology, psychology, and sociology.

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The *International Series on Sport Sciences* serves not only as a valuable source of authoritative up-to-date information but also helps to foster better understanding among sport scientists on an international level. It provides an effective medium through which researchers, teachers, and coaches may develop better communications with individuals in countries throughout the world who have similar professional interests.

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Volume 7
Pařízková and Rogozkin. **NUTRITION, PHYSICAL FITNESS, AND HEALTH**

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Preface

Interrelationships between nutrition and physical activity, representing the most important aspects of energy input and output, have become a topic of increasing interest because of their mutual dependence and the important role of both in terms of their optimal or impaired balance in the functional capacity, fitness, and health status of the organism. In 1975, at the occasion of the Xth International Congress of Nutrition in Kyoto, Japan, a special committee devoted to these subjects was established by the International Union of Nutritional Sciences (IUNS), which is associated with UNESCO. The aim of this Committee is to collect all available information on research in this particular area, to encourage or organize scientific meetings, and to summarize and define recommendations for practice. The present volume is a result of this Committee's activities.

Research work in nutrition, functional capacity, and fitness has been developing successfully in the past years, as witnessed by numerous international meetings—e.g., regular conferences on "Nutrition, Dietetics and Sport" in Bordighera in 1976 and Rome in 1973, the "International Symposium on Athletes Nutrition" in Leningrad in 1975, the special symposium on "Nutrition and Physical Fitness in Man" held within the framework of the Xth International Congress of Nutrition, and many others. There already exist many surveys and monographs that deal with this problem, but new information is accumulating and further research is underway. Therefore, this volume was compiled.

Relationships between caloric intake and output, nutrition, and physical activity have had an important impact on growth and development from the very beginning of life. A characteristic motor pattern and volume of physical activity is claimed to be related to special body physique (obviously also to a special metabolic pattern and functional capacity) in infants, as well as in children and adolescents. This applies also to adult age groups, and has great importance not only for general fitness but also for performance capacity from the professional point of view, with special relevance for the economic production and health prognosis in later periods of life. These problems have been studied in various surveys of human subjects and analyzed in greater detail in fundamental research in experimental models with laboratory animals.

Diet that is quantitatively and qualitatively deficient, and overnutrition, i.e., too abundant and inadequately balanced diet, are serious problems of malnutrition, especially when they are not maintained in a proper relation to the level of physical activity and muscular work. Obviously, protein energy malnutrition and its consequences for somatic and mental development, as well as functional capacity, is a most important problem in developing countries, but hyperalimentation accompanied by hypokinesia is considered to be one of the most important risk factors for cardiovascular disease in industrially developed countries, according to the World Health Organization (WHO). Unfortunately, along with technological advances, they are transferred to certain social strata in other areas of the world.

Therefore, we have tried to find evidence for the aspects mentioned, all of which are assumed to be very important tasks for the IUNS committee. Adequate criteria for optimal nutrition in special ecological situations have to be defined more accurately, including desirable functional capacity and health prognosis. Standard values of height and weight for individual age categories from developed countries are not the optimum for all places in the world, but they are often used as such. This area of research deserves increased emphasis.

Throughout the world, champion sport attracts more interest than any other social phenomenon. Nutrition of athletes related to special kinds or phases of training and competition for different age categories is a topic given enormous attention by sport medical doctors, coaches, and trainers. Since ancient times, there have existed recommendations and recipes for athletes that were assumed to ensure the optimal level of performance; however, conclusive decisions have never been reached, and it remains a task for many laboratories and institutes around the world.

An attempt was made in this publication to indicate some of the more general aspects that make the interrelationships between nutrition, physical activity, and fitness so important. The role of individual nutrients, water, and electrolytes is discussed and documented by experimental data gained both in human subjects and laboratory models with animals. This volume, which was arranged in a brief period of time, does not aspire to cover the entire area. It rather provides some information about more recent progress in the research in nutrition and exercise, which is surely not complete and is sometimes contradicting. However, this is characteristic of the situation at present; discrepancies are often attributable to the fact that exercise is taken generally, i.e., the pecularities of dynamic or static work loads are not considered.

Many renowned research workers were asked to contribute; not all were able or willing to fulfill our request, and those who did prepared their contribution in a way corresponding to their ideas, which was fully respected. The intention was not to interfere with the area of exercise biochemistry, although some overlapping was unavoidable. This research area is excellently covered by a group of distinguished scientists who presented their data at the occasion of the International Symposia of Exercise Biochemistry (Brussels, 1968; Magglingen, 1973; Quebec 1976) and elsewhere. Some of these research workers who are interested more in the impact of special diets nevertheless contributed to this volume.

Let us hope this collection of papers will not only give summarized information, but will also constitute another step in the development of studies concerning nutrition, physical activity, and performance, and will encourage future research in this field so important in practical life.

J. Pařízková
V. A. Rogozkin

NUTRITION, PHYSICAL FITNESS, AND HEALTH

Contents

Metabolic Aspects of Performance Capacity

Food Intake and Energy Utilization

D. S. Miller

This chapter is limited to data on man, because man exhibits important differences from other species. It is not implied that man can cheat the general principles of physiology, biochemistry, or even the laws of thermodynamics—man simply exhibits far wider genetic and behavioral variations than do the animal species normally studied by science. There are many reasons for this. Whereas laboratory, farm, and domestic animals have been selected for specific characteristics, there are strong taboos in all human cultures that prevent such selection from taking place in man. Farm livestock have been developed with a high efficiency of energy utilization for the economic benefit of the farmer, and the laboratory rat is so genetically uniform as to be often homozygous. It could be argued that natural selection in man might have favored those individuals who were good utilizers of food such that they were more resistant to famine, but such individuals would have become obese in times of plenty, and thus less able to avoid the hazards of primordial predators. It is not surprising, therefore, that we find among any human population a wide range of energy utilization not found among domesticated animals. Further unique features of man's existence are an extended period of development and longevity. Domesticated animals reach maturity within a year or two, and few studies on middle-aged or old laboratory animals are recorded. On the other hand, man takes 20 years to reach maturity, and can maintain his mature weight within narrow limits for an additional 50 years. The most interesting aspect of this ability is that he can do this on a wide range of food intakes, and it is this factor that makes the statement of human energy requirements so difficult.

There is much controversy today as to the nature of homeostatic controls for the regulation of energy balance in man. Undoubtedly controls of food intake exist in man as in other animals, but it would seem that these are coarse controls, easily overridden by the higher centers of the brain. One has only to compare the laboratory rat eating his cubed diet for months on end with the gourmet entertaining his friends and colleagues at lunch, working through an extensive menu of delectable dishes, to realize that human food has sensual, social, cultural, and economic values quite apart from its nutritional content. This has resulted in the growing belief that control of the efficiency of utilization of energy must also be important in man if we are to explain the ability of some of us to maintain weight over long periods of time without even trying.

VARIATIONS IN FOOD INTAKE

The central problem in this field is to explain how apparently similar individuals can maintain energy balance on widely differing food intakes. Widdowson (1962) has demonstrated that for any 20 people of the same age, sex, and occupation, one individual could be found who was eating twice as much as another person. She also stated that there are some infants who eat even more than some adults. Since these results were originally published, all dietary surveys on individuals have shown a similar variation irrespective of the length of the study or the level of the energy intake. How is this possible? Widdowson's data indicate that the explanation is not to be found in variations in body weight (despite the recent recommendations of FAO/WHO, 1974), because expressing the figures in terms of intake per kg body weight shows an equally wide variation. In studies of different populations—whether from different countries or from different social classes within those countries, it is shown that the mean energy intakes of groups of adults also show wide variation. For example, the mean intake of male Americans is more than 3,000 kcal, but that of Ethiopians is only 2,000 kcal per day. It is difficult to believe that the explanation of these differences is attributable to differences in physical activity, because Americans live in an affluent, labor-saving society, and Ethiopians are subsistence farmers. However, it is clear that the explanation must lie in differences in energy expenditure, and that this results largely from differences in heat production—i.e., thermogenesis. Increased thermogenesis can arise from a number of causes (Miller, 1975): it may be induced by cold, stress, drugs in common use, and also by diet. Dietary-induced thermogenesis is the manifestation of poor food utilization; it has been variously described as Specific Dynamic Action, the thermic effect of food, and luxuskonsumption, but these terms have led to much confusion in the literature, and until the phenomenon is properly understood, the general term, dietary-induced thermogenesis (DIT), should be used.

Experimental Overfeeding

There is now a mass of evidence to show that weight changes in response to overeating in man are not always positive and cannot be predicted by simply dividing the excess energy intake by a factor representing the energy density of adipose tissue. The earliest experiments were by Neumann (1902) and by Gulick (1922). Both conducted experiments on themselves continuously for several years and demonstrated that their body weights could be maintained on energy intakes 40% above their customary intake. In the author's own experiments (Miller and Mumford, 1967), 49 subjects have now been overfed. They have been given a variety of diets for periods up to 8 weeks. The customary food intake of each subject was measured during the week previous to overfeeding. During the experimental weeks they were encouraged to eat as much food as possible, but in any case a minimum of 1,000 kcal extra each day. Initially, the effects of eating diets of high and low protein contents were compared, but subsequent experiments involving comparisons of nibbling (14 meals/day) and gorging (2 meals/day), high and low sodium diets, and diets containing a high proportion of sucrose or starch were undertaken. With the exception of those subjects fed two meals a day, there was a marked adaptation to the increased energy intake such that the rate of gain decreased throughout the experiment. This resulted in very small weight gains compared with the extra food consumed, and most of this weight was put on during the first week of overfeeding. Some individuals consumed 10,000 excess kcal/week and showed a weight loss.

These experiments have been repeated by a number of workers, but the most notable are the marathon overfeeding experiments of Simms and co-workers (1973). They persuaded their subjects to consume 7–10,000 kcal/day for periods of 200 days or more—an excess of food intake of approximately 1 gigacalorie (million kcal). The subjects were expected to increase their body weights by 20–25%, and measurements were made of the energy cost of maintenance before and after overeating. However, not all subjects were equally successful in gaining weight. Some reached their goal with difficulty, but others failed to gain even though they were consuming more than those who gained readily. Their data for the energy cost of maintenance was for the overfed 2,700 kcal/m^2, compared with 1,800 kcal/m^2 before the experiment.

There are a number of possibilities to account for the lack of weight gain in all these experiments. Reduced digestibility of food and increased physical activity are easily eliminated by making the appropriate measurements. However, there has been some controversy as to the relative importance of changes in body composition and increased