MODERN NUTRITION *in* Health *and* Disease

MICHAEL G. WOHL
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MODERN NUTRITION
in
HEALTH and DISEASE

Dietotherapy

FOURTH EDITION EDITED BY

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Preface

RETRACING some of the earliest steps in the preparation of *Dietotherapy*, we are struck by how much has changed in the field of nutrition since 1945. We were then concerned with frank deficiency diseases. Today, only occasionally do we see deficiency diseases on a dietary basis in this part of the country. We do encounter some deficiency states due to stress of disease, and inadvertent malnutrition may still, of course, result from some therapeutic procedures.

A new class of nutritional diseases—inborn errors of metabolism—has come to the fore. These are associated with faulty body chemistry due to genetic enzyme deficit; as the result of such a disease, unless a specific nutrient is eliminated from the diet, brain damage may develop.

The 4th edition of *Modern Nutrition in Health and Disease* has been completely revised and much of it rewritten. It represents an authoritative and up-to-date discussion of the points mentioned above and all the other newer aspects of nutrition that have a bearing on the prevention of disease or the cure of illness. Important additions include three new chapters: (1) Naturally Occurring Toxic Foods; (2) Evaluation of Nutritional Status in Population Groups; and (3) Nutrition and Brain Function. Five chapters have been entirely rewritten by leading authorities.

This volume has been designed to serve both as a textbook on nutrition and as a ready reference book for practitioners in the fields of medicine, nutrition and public health. We hope that it will serve to expedite the application of advances in the science of nutrition to the benefit of man in health and disease.

The book, of course, could not have been revised without the wholehearted support of the contributors: our indebtedness to them is very great. We also wish to acknowledge our obligation to the staff of Lea & Febiger for their indispensable help in bringing the text to press.

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PART I. NORMAL NUTRITION

Part I. Normal Nutrition

CHAPTER

1

Body Weight, Body Composition and Calorie Status

By Ancel Keys
and
Francisco Grande

The body is, in the most literal sense, the product of its nutrition. Though the transformations are profound, nutrition begins with the foodstuffs and proceeds to the material end result, the living body and its functions. The most elementary, but certainly not the least important, aspect of nutrition is the gross mass of tissue it produces and maintains. The most obvious, and in many populations perhaps the most common, nutritional defects are those caused by gross calorie imbalance.

The opposite defects of emaciation and obesity have always been with us and this is true today in all populations. Calorie undernutrition is the most common form of malnutrition in underdeveloped countries but, even in the midst of plenty, starvation caused by disease is common because many illnesses interfere with the appetite or the assimilation of food. In the simplest of societies obesity may be rare, either because of chronic food shortages or because physical exercise is an effective preventive, but as society becomes more specialized, more prosperous and more sedentary, an excessive accumulation of body fat tends to be the rule unless it is consciously combated.

Except for changes in hydration, gain of body weight over a period of time is an expression of positive calorie balance, that is, an excess of calorie intake over expenditure and, conversely, weight loss is an expression of calorie deficit. But it must be borne in mind that, as discussed later, there is no simple relationship between calorie balance and the rate of weight gain or loss at a given time. Finally, it is possible to maintain constant weight and still be in positive calorie balance; this can happen when muscle is replaced by fat and when body water is lost in the presence of positive calorie balance.

The first step in nutritional evaluation is a calorie judgment; is the patient too thin or too fat? Mere inspection of the body allows rough classification. In extreme examples, obesity and emaciation are readily recognized, even when the presence of edema or dehydration complicate the picture. But more moderate departures from normality present problems of evaluation and even at the extremes there is the need to determine the degree of abnormality and its response to treatment. Elementary considerations demand biochemical and functional definitions and measurements of obesity, fatness, overweight, underweight, leanness and emaciation. Metabolic analysis, of course, cannot even begin properly without consideration of the gross composition, and its changes, of the body.

Until recently, besides the impressionistic methods of gross inspection and digital feel, gross body weight, sometimes supplemented with a few measurements of external dimensions, had to suffice for studies on living man.

Fortunately, new methods are now at hand for analysis of the body mass into metabolically distinct components.[66,104] These, together with the more widespread application of statistical methods and concepts, provide increasingly useful and precise norms for guidance in calorie nutrition.

BODY WEIGHT

The gross body weight *per se* has some direct metabolic significance. To the extent that it represents the size of the cell mass of the body it determines the Basal Metabolic Rate. The metabolic cost of physical activity is determined by the body weight since most of the energy cost of physical activity is expended in simply moving the body around. With a fixed amount of activity—number, extent, speed and force of movements—energy expenditure tends to be directly proportional to gross body weight.[42,62] This not only affects calorie requirements; there also is the integral need to provide digestion, respiration and circulation for this metabolism.

Actually, grossly overweight persons tend to be relatively inactive; the movements they make are expensive in calories but they make fewer movements than persons of average weight. Many recent studies show that overweight persons are not characterized so much by large food consumption as by physical inactivity.[59,76,78] However, when a heavyweight has to move quickly there is an excessive demand for energy and this may mean a strain on one or more vulnerable organs or functions. This may contribute to the high mortality rate of overweight persons.

Insurance companies report an excessive death rate of overweights from a variety of causes, including accidents. A heavy body is an impediment in avoiding many accidents simply because it is harder to move or to change the direction of movement of a heavy body. Further, the damaging force in a fall is increased with increasing body weight. It should be noted that over 20 per cent of all accidental deaths in the United States are caused by falls.

Nevertheless, the major importance of the body weight is its association with body fatness. The amount of fat in the body may be considered as an expression of the calorie balance status. It is a common error to regard overweight and obesity as identical. Obesity means excessive fatness and it is essential to adhere to this definition.[57,66] Athletes are often overweight but underfat.[9] It is safe to conclude that a middle-aged man who is 30 or more pounds heavier than the average man of the same height is obese, that is, overfat. But, at lesser degrees of overweight, the relationship between obesity and overweight is not close, particularly at younger ages.[19,20,21]

Many sedentary persons are excessively fat but not overweight, while the opposite condition, overweight without being fat, is common among people doing heavy physical work. The two conditions are, in fact, metabolic opposites, the one tending to result from lack of activity, the other from excessive activity. Attention to this discrimination discloses differences in characteristics pertinent to circulation and health.[112] Besides such physiological differences between fat persons and overweight persons who are not fat, there are emotional and psychological differences of perhaps even greater significance.

Besides distinguishing between fat and muscle in the gross body weight, variations in the water content of the body must be considered. In ascites 5 to 10 kilograms of fluid in the abdominal cavity may be encountered and much larger totals of edema fluid are not rare. One of Simonart's[103] starved patients lost 20 kilograms in a week while his nutriture was improving and this is by no means unique. Extreme edema is readily detected but more moderate variations in hydration are not easily recognizable. Clinical recognition of the presence of edema requires an accumulation of the order of 5 to 10 per cent of the total body weight as excess water.[66,68] The variable contribution of water to the total body weight of clinically healthy persons is reflected in the weight

fluctuations seen on reducing diets under controlled conditions.[83]

Another contributor to confusion about the meaning of the total body weight is the variable weight of the bony skeleton. The mineral mass in the adult skeleton averages something like 6 per cent of the normal body weight of the adult but, in different persons, it may be as low as 4 per cent or as high as 9 per cent.[66]

Perhaps a more important contribution of the skeleton to the body weight is through its form. Overweight and underweight are commonly computed on the basis of weight for height. But a broad and short skeleton automatically means a large body weight per unit of height and, so far, no system has been devised to allow for this in a practical manner. The body "frame" types discussed below are theoretical concepts devoid of real utility in the absence of agreed methods of measurement and classification.

The "constancy" of Body Weight. The literature on body weight contains only limited information about daily weight changes. Rapid fluctuations of body weight do, however, occur with no apparent relation to changes in calorie intake, energy expenditure or health status. These short-term fluctuations are difficult to understand but they should be taken into account in metabolic experiments, especially when they involve limited periods of time. In a group of 44 men living under highly controlled conditions, Durnin[30] observed day-to-day changes of body weight up to 1 kg. Similar observations have been reported by Edholm.[32] Elkinton and Danowski[36] measured body weight of a man on 53 out of 56 days and found a standard deviation of ± 0.86 pound, equivalent to ± 0.51 per cent of his weight. Changes of body weight in women have been studied in relation to the menstrual cycle. Taggart[110] studied the body weight of a non-pregnant woman for a period of 80 days. The body weight during the period changed from 61.5 to 63.9 kg with daily fluctuations up to 0.8 kg. These changes were not related to the menstrual cycle.

Most of the short-time fluctuations of body weight can be explained by changes in the water content of the body. These fluctuations, however, do not detract from the fact that over periods of a week or more food intake and energy intake are closely balanced and the body weight remains relatively constant.[32]

Body Weight Standards. Until lately almost all statistical evaluations of calorie status, obesity, emaciation, and gross nutritional health have been based simply on the gross body weight as related to height. Comparison of a person's actual weight, M, with his "standard" (tabular) weight, S, is the most widely used criterion of leanness-fatness. The degree of over- or underweight may be expressed as the percentage deviation of the actual from the standard weight, $\triangle\% = (M-S)/S$, or as "relative body weight," $R = 1000M/S$. In the United States the standard of reference has long been the tables of average weight for height and age, originally published by the Association of Life Insurance Medical Directors and the Actuarial Society of America in 1912 under the title, "Medico-Actuarial Mortality Investigation" (New York). These tables are still the most widely used and are summarized in Tables 1–1 and 1–2.

Elsewhere[63,65] we have discussed the limitations of these tables which merely give the average values for men and women of specified ages who obtained life insurance policies at standard premium rates from 1888 to about 1905, mostly in urban centers on the eastern seaboard. The heights and weights were recorded as for "ordinary clothing"; what this means today is questionable. However, for men at least, similar values may apply approximately to the undressed state, that is, in socks and shorts, because the heel height (about 1 inch) roughly counteracts the clothing weight customary half a century ago. For women the application is more difficult because of the variability of heel height and the great reduction in female clothing weight over the intervening years.

More recently, tables have come into use which list body weights for the same height

under three headings: "light" or "small frame," "medium frame," and "heavy" or "large frame." The medium frame values correspond to the averages in the older tables and the "light" and "heavy frame" weight values are simply some 5 to 8 per cent smaller or larger, respectively. This is in recognition of the obvious fact that appropriate weights for the same height must differ according to the skeletal type. Unfortunately, however, there is no accepted system for deciding who has a "light frame," and so on, and no actual evaluations of frame size were made in developing the tables.

Apparently the observed frequency distributions of the weight values used for the original tables of 1912 (where frame was not considered) were merely divided into thirds. The lighter third of men of a given height and age were arbitrarily defined as having a "light frame" and the mean weight of this group was then considered to be the average body weight of men of "light frame" of the given height and age. In other words, these

Table 1–1. Graded Average Weight in Pounds of Men of Different Statures at Various Ages*

Height, Inches	*Age, Years*							
	20	*25*	*30*	*35*	*40*	*45*	*50*	*55*
60	117	122	126	128	131	133	134	135
62	122	126	130	132	135	137	138	139
64	128	133	136	138	141	143	144	145
66	136	141	144	146	149	151	152	153
68	144	149	152	155	158	160	161	163
70	152	157	161	165	168	170	171	173
72	161	167	172	176	180	182	183	184
74	171	179	184	189	193	195	197	198
76	181	189	196	201	206	209	211	212

* Davenport, C. B.: Body Build and Its Inheritance. Publication 329, Carnegie Institute of Washington, 1923.

Table 1–2. Graded Average Weight in Pounds of Women of Different Statures at Various Ages*

Height, Inches	*Age, Years*							
	20	*25*	*30*	*35*	*40*	*45*	*50*	*55*
56	106	109	112	115	119	122	125	125
58	110	113	116	119	123	126	129	129
60	114	117	120	123	127	130	133	133
62	119	121	124	127	132	135	138	138
64	125	128	131	134	138	141	144	144
66	132	135	138	142	146	149	152	153
68	140	143	146	150	154	157	161	163
70	147	151	154	157	161	164	169	171
72	156	158	161	163	167	171	176	177

* Davenport, C. B.: Body Build and Its Inheritance. Publication 329, Carnegie Institute of Washington, 1923.