ADVANCES IN EXPERIMENTAL MEDICINE AND BIOLOGY

Volume 49

NUTRITION AND MALNUTRITION

Identification and Measurement

Edited by
Alexander F. Roche and Frank Falkner

NUTRITION AND MALNUTRITION

Identification and Measurement

Edited by

Alexander F. Roche and Frank Falkner

The Fels Research Institute
Yellow Springs, Ohio

PLENUM PRESS • NEW YORK AND LONDON

Library of Congress Cataloging in Publication Data

Burg Wartenstein Conference on Physical Anthropology and Nutritional Status, 1973.
Nutrition and malnutrition.

(Advances in experimental medicine and biology, v. 49)
Includes bibliographies.
1. Nutrition—Congresses. 2. Malnutrition—Congresses. 3. Anthropometry—Congresses. I. Roche, Alexander F., 1921- ed. II. Falkner, Frank Tardrew, 1918- ed. III. Title. IV. Series. [DNLM: 1. Anthropology, Physical—Congresses. 2. Nutrition—Congresses. 3. Nutrition disorders—Congresses. W1 AD559 v. 49 1973 / QU145 B954n 1973]
TX345.B8 1973 641.1 74-13950
ISBN 0-306-39049-3

Proceedings of the Burg Wartenstein Conference on Physical Anthropology and Nutritional Status held August 6-15, 1973

A Division of Plenum Publishing Corporation
227 West 17th Street, New York, N.Y. 10011

United Kingdom edition published by Plenum Press, London
A Division of Plenum Publishing Company, Ltd.
4a Lower John Street, London W1R 3PD, England

Printed in the United States of America

NUTRITION AND MALNUTRITION

Identification and Measurement

ADVANCES IN EXPERIMENTAL MEDICINE AND BIOLOGY

Recent Volumes in this Series

Volume 40
METAL IONS IN BIOLOGICAL SYSTEMS: Studies of Some Biochemical and Environmental Problems
Edited by Sanat K. Dahr • 1973

Volume 41A
PURINE METABOLISM IN MAN: Enzymes and Metabolic Pathways
Edited by O. Sperling, A. De Vries, and J. B. Wyngaarden • 1974

Volume 41B
PURINE METABOLISM IN MAN: Biochemistry and Pharmacology of Uric Acid Metabolism
Edited by O. Sperling, A. De Vries, and J. B. Wyngaarden • 1974

Volume 42
IMMOBILIZED BIOCHEMICALS AND AFFINITY CHROMATOGRAPHY
Edited by R. B. Dunlap • 1974

Volume 43
ARTERIAL MESENCHYME AND ARTERIOSCLEROSIS
Edited by William D. Wagner and Thomas B. Clarkson • 1974

Volume 44
CONTROL OF GENE EXPRESSION
Edited by Alexander Kohn and Adam Shatkay • 1974

Volume 45
THE IMMUNOGLOBULIN A SYSTEM
Edited by Jiri Mestecky and Alexander R. Lawton • 1974

Volume 46
PARENTERAL NUTRITION IN INFANCY AND CHILDHOOD
Edited by Hans Henning Bode and Joseph B. Warshaw • 1974

Volume 47
CONTROLLED RELEASE OF BIOLOGICALLY ACTIVE AGENTS
Edited by A. C. Tanquary and R. E. Lacey • 1974

Volume 48
PROTEIN–METAL INTERACTIONS
Edited by Mendel Friedman • 1974

Volume 49
NUTRITION AND MALNUTRITION: Identification and Measurement
Edited by Alexander F. Roche and Frank Falkner • 1974

Preface

The Burg Wartenstein Symposia have become rightly celebrated for achieving their original purpose: to be of service and interest to the anthropological profession as a whole and to contribute to related sciences. We are specially grateful to the Board of Directors of the Wenner-Gren Foundation for Anthropological Research for the award of a symposium on Physical Anthropology and Nutritional Status. We had considered that such a subject was timely and that an inter-disciplinary approach would contribute useful knowledge in a most important area--particularly in the field of child health. This publication of the proceedings will show the degree of success of these aims.

Mrs. Lita Osmundsen, Director of Research at the Wenner-Gren Foundation, not only steered us in the early stages but, during our delightful time at Burg Wartenstein, and subsequently, she has been that most charming of crosses--den mother and first class science administrator. We are deeply grateful to her. And grateful, too, for the organization and friendly warm spoiling by the Wenner-Gren staff in residence at Burg Wartenstein. Our nutritional status was high. Nothing was too much trouble for them and it was a wrench to leave and say goodbye to them.

The Foundation has since supported our efforts towards this publication. Here we owe a very special debt of gratitide to the cooperation and friendly expertise of Mr. Seymour Weingarten, Senior Editor of the Plenum Publishing Corporation, aided by Mr. John Matzka, Managing Editor of this Corporation.

Finally, some of us were originally doubtful about the prognosis of being sequestered in an Austrian castle--however beautiful--for one week with some 20 scientific colleagues. Those having these thoughts could not have been proved more wrong. We are grateful, above all, to the participants for their contributions, then and since, and indeed for making the outcome so happy, healthy and lusty.

Alex F. Roche

Frank Falkner

Co-Chairmen

Contents

DEFINITION OF THE PROBLEM

E. F. Patrice Jelliffe and Michael Gurney

From the University of California, Los Angeles, California, USA, and Caribbean Food and Nutrition Institute, Kingston, Jamaica

The gross dimensions of the problem facing workers in the nutritional field are well known, but definition of the problem is difficult.

"Nutritional status" per se is an abstract concept and to assess it, workers have had at their disposal methods, measurements and techniques that are still being criticized, partially accepted, refined and continuously evaluated. Such relatively slow progress would be considered inefficient in any non-medical field. However, the ever changing aspects of the complex problem of human malnutrition, with its multiple interrelationships, cannot be underrated by experienced nutrition workers.

To diagnose accurately the problems of community nutrition, a need exists for suitable methods and measures that can assess accurately, simply and inexpensively, the nutritional status of populations at risk. Recent concern with problems of community nutrition has clearly indicated this need to be able to define the extent of malnutrition in affected communities. Newer methods and techniques have been tried, particularly in the past decade, to measure the results of dietary deficiencies (and excesses) of total calories (energy) and of protein, especially in young children. These methods have been concerned with the assessment of the prevalence and

incidence of protein-calorie malnutrition in early childhood, but also with the apparently increasing problem of infantile obesity. The assessment of the prevalence of malnutrition is an essential part of community nutrition surveillance.

The measurement of the extent of the problem is needed for various reasons. First, such assessments of prevalence can be used as baselines to measure the effectiveness of planned intervention programs, or of unplanned changes in the particular community, or of secular trends.

Data showing the prevalence of malnutrition and its geographical, economic and social distribution within a country or region are plainly of the greatest importance in suggesting how limited resources can be deployed to areas of greatest need. In addition, the availability of hard figures, presented in an understandable form, showing the commonness of malnutrition in a particular community can be valuable in trying to stimulate the provision of the necessary action and resources from fund-controlling administrators and politicians.

The need for methods of assessing malnutrition, particularly in young children, has come very much into focus as a result of other large-scale studies on a variety of important topics, including the relationship between mental development, immunity and nutritional status.

Lastly, on an individual basis, there has been an increasing awareness of the need to monitor growth to detect children with early malnutrition and to screen those at risk as early as possible. This has been undertaken by using various forms of growth charts, such as the one introduced and popularized by Morley.[1] The latter type of chart not only assesses the growth progress of the child under surveillance but is also an excellent teaching aid for medical and paramedical personnel, as well as the child's parents, particularly the mother.

METHODS OF NUTRITIONAL ASSESSMENT

The nutritional assessment of human communities can be undertaken in various ways. These have been divided into three main groups of approach--direct, indirect, and ecological.[2] The present concern will be mostly with the direct assessment of nutritional status in human communities. This can be considered under the four headings--clinical signs, biochemical tests, tissue tests and anthropometry. Each of these approaches has its limitations as a diagnostic tool. The most appropriate blend of these methods will have to be used in surveys concerned with the etiology and treatment of malnutrition and the evaluation of the success of intervention programs.

Clinical Signs

It is increasingly appreciated that clinical signs, which should be recorded selectively to give a general over-view of the local situation, are very variable and highly subjective[3] and depend greatly on the experience of the clinician. They need to be supplemented by other data.

Biochemical Tests

These include amino acid inbalance, serum albumin, blood vitamin levels, hydroxyproline excretion, and urinary creatinine. They require samples of blood or urine to be taken in the field. These samples must be preserved and transported for analysis in a specialized laboratory. Finally, the results must be interpreted correctly.[2] None of these steps is easy, and recently there has been an increasing tendency to use such tests selectively, and sometimes only on a subsample, because of their cost and the difficulties encountered under field circumstances.

Tissue Tests

Several of these have been introduced in recent years, such as examination of hair root morphology.[4] Samples of hair are easy to collect from children, easily stored, transported and examined. Hair, as a sensitive protein tissue, indicates the early effects of protein malnutrition by changes in bulb root diameter when serum albumin levels in the blood are still within normal limits. The results of this test can be interpreted without knowledge of the precise age. The findings are useful if combined with anthropometric measures, [5,6] such as arm circumference, but used alone they would not yield sufficient information.

Anthropometry

This discipline provides measures of body size and shape, and also indicates the dimensions of some body compartments. By general consensus of those working in this field, nutritional anthropometry has a most significant role in the direct assessment of nutritional status in communities, especially in young children, where the problem of malnutrition is most severe and extensive. In addition, anthropometry may play a considerable role in the nutritional assessment of older children and adults.

It must be appreciated, however, that the growth of children is influenced by a variety of factors such as socioeconomic status of the parents and the sex and birth-rank of the child. Climate, seasonal variations, infections, parasites and psychological factors also, directly or indirectly, affect the child's nutritional status.

PROBLEMS OF ANTHROPOMETRIC ASSESSMENT

The anthropometric assessment of nutritional status is concerned principally with the detection of protein-calorie malnutrition of early childhood (PCM), especially in cross-sectional surveys in less developed countries. However, as with the other methods, there are problems

in the selection of both measurements and methods and their standardization, in the assessment of age and in the selection of reference standards.

Selection of Measurements and Methods

The selection of measurements and methods that must be simple and replicable, using suitably trained staff and accurate apparatus, will depend on the information sought and the funds and staff available. In addition, when the problem of PCM is considered, accurate knowledge of the child's age is a key factor in the selection of measurements.

Usually PCM is the main problem to be assessed by anthropometric means. Four measurements are essential--weight, height (length), arm circumference and triceps fatfold. In addition, head and chest circumferences are frequently included in the "basic six." The measurements included will depend also on the objectives of the survey and considerations including logistics and the distance from the home-base. For example, in a famine or disaster area children can be screened by measurement of the arm circumference alone,[7] or by the QUAC stick which groups children on the basis of arm circumference for height.

Recent studies suggest that different measurements may be interpreted in relation to not only the severity of PCM, but also to its acuteness or chronicity, and to its type, in relation to depletion of calorie stores (fat) or of protein stores (muscles).[8] A low body weight or arm circumference is associated with a relatively acute or recent onset of malnutrition. By contrast, a low height-for-age indicates malnutrition of some chronicity. The arm circumference can be analyzed, together with the triceps fatfold to permit separate analysis of the fat and muscle cross-sectional <u>areas</u>, indicating whether the deficiency is principally of protein or calories.[9]

While differentiation of PCM into various categories seems possible with the measurements previously mentioned,

there is a need for confirmation of their usefulness in diverse ecologies. In addition, an unsolved problem concerns the possible duplication of information obtained by these different measurements. In the limited time available in surveys, unnecessary duplication must be eliminated.

Standardization of methods and techniques is necessary to ensure comparability of results among countries, and to make comparisons possible between surveys made at different times within the same community. Currently such comparisons are extremely difficult and unreliable because differences exist among the techniques used in surveys in various parts of the world and because there is a lack of agreement as to which of the available reference standards should be used for comparison.

There is a need to standardize anthropometric techniques but debate continues concerning methods and practices. Standard techniques should be followed and the precise details of the methods used, including the apparatus, should be documented and reported in all studies.

Usually only limited funds are available to undertake community studies to investigate nutritional status. Therefore, the most economical and simplest measurements and equipment, that can give scientifically valuable and replicable results, must be identified. Consideration has to be given to the cost of the equipment and staff needed to prepare and manage the survey, and to analyze and interpret the data. Anthropometry can be undertaken in developing countries employing specially trained supervised para-medical personnel. The time taken to undertake various types of measurements needs consideration. For example, the QUAC stick method can be applied in only a fraction of the time needed to weigh and measure the length of a preschool child.

Likewise, equipment must be sturdy, simple, inexpensive and easily transportable. Many different types are used in various parts of the world making the standardization of methods a difficult task. However, a recent survey into types of commonly used and available scales showed that for mobile field surveys of young children,

a portable Salter spring balance gave sufficiently accurate results and was relatively cheap and easily transportable. Considerations of costs are important in the selection of anthropometric equipment, including length boards and fatfold calipers. One advantage of the measurement of arm circumference is that the equipment required is only a non-stretch centimeter tape measure.

Availability of Precise Chronological Age

If the precise age of young children is known, the selection of measurements and their interpretation become much easier. In most parts of the world, the precise ages of young children are unknown, because they are not of social significance. Also, in many communities, documentation regarding the correct age is not available. Use can be made of horoscopes, birth certificates or baptism certificates, if such documents exist.

When the precise age of the young child cannot be ascertained, it may only be possible either to estimate the age to the nearest year, or to classify children roughly as preschool children (one to five years). This complicates the choice of measurements to be made and makes their interpretation more difficult.

Under these circumstances, it is essential to use an age-independent ratio, which gives information concerning nutritional status (i.e., chest circumference/head circumference), or to compare a measurement which reflects a nutritionally labile body tissue (body weight or arm circumference),[7] with a measurement of body tissue that is much less affected by malnutrition, and which cannot decrease (height, arm length or head circumference).[10] Attempts have been made to define a "dental second year" as an approximate measure of age to test the validity of a low chest circumference/head circumference ratio, or arm circumference as field tests for PCM.[11]

Many composite indices have been used in field surveys during the past two decades; following the pioneering example of some psychologists who, in the 1950's wished

to extrapolate meaningful results from multiple tests applied to their patients and used statistical techniques of multivariate analysis. Such techniques aim to replace numerous correlated measurements by a smaller number of uncorrelated linear combinations of these measurements.

Among the composite indices were, to name but a few, the scoring system,[12,13] the point system[14] (modified by Timmer[15]), and Kanawati's "index of thriving"[16] which uses the sum of scores of four anthropometric measures, (weight, midarm circumference, height or length, and head circumference). Furthermore, Burgess et al.[17] and Moffat[18] assessed PCM on the basis of three or more signs including one abnormal anthropometric measurement. When composite anthropometric measurements are used, the component measures must be simple to collect, and must each measure an unrelated major component of the growth failure, affecting different body tissues and physical dimensions, that is seen in the various forms of protein calorie malnutrition.

Hanafy et al.[19] used the nutritional state index of the infant (N.S.I.I.). This is based on weight and arm circumference expressed as percentages of predicted values and serum albumin as a percentage of normal (3.8 g/100 ml) and the nutritional state index of the mother (N.S.I.M.). The latter is based on weight, arm circumference, serum albumin, urea nitrogen and creatinine nitrogen.

In recent years, however, emphasis has been given to anthropometric measurements that are truly age independent, provided the children can be grouped as being of preschool age (one to five years). These measurements include arm circumference x 100/height,[20-22] weight/height, which Gopalan[22] found was highly correlated with undernutrition in young children as judged by a low weight for age or by the presence of clinical signs. Other indices include weight/height$^{1.6}$, arm circumference/stature[23] and arm circumference/length of upper arm x 100.[24] The latter index possibly represents environment (nutrition)/genetic variables. Arm circumference alone has been employed in surveys, using an approximate standard for the whole age range from one to five years. Using