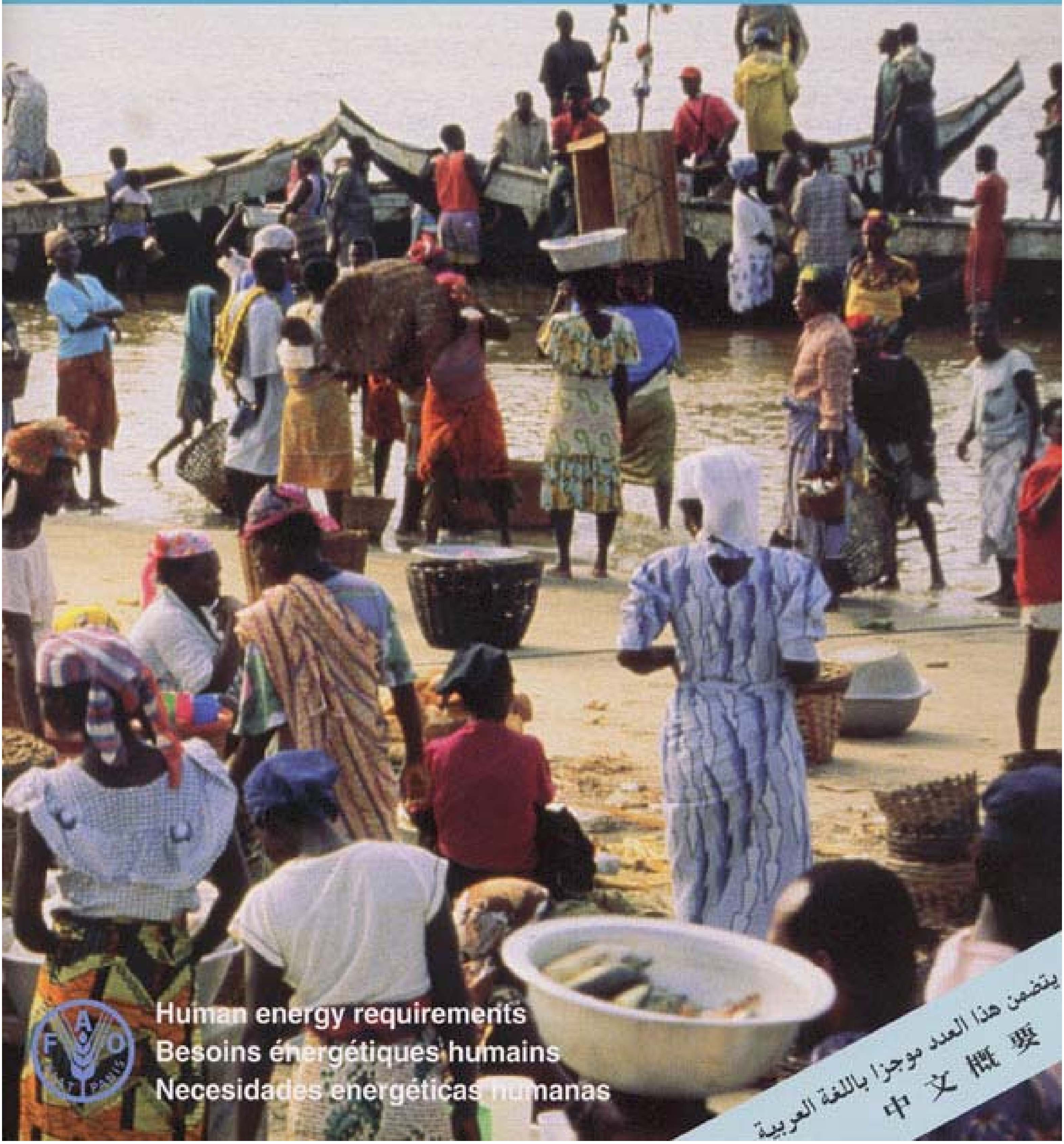
ISSN 1014-806X

30
2002

Food, Nutrition and Agriculture
Alimentation, Nutrition et Agriculture
Alimentación, Nutrición y Agricultura



Human energy requirements
Besoins énergétiques humains
Necesidades energéticas humanas

يتضمن هذا العدد موجزا باللغة العربية

中文概要

A PUBLICATION OF THE FAO FOOD AND NUTRITION DIVISION

Food, Nutrition and Agriculture reflects the concerns of the Food and Nutrition Division of FAO, covering topics such as community nutrition, food quality and safety, nutrition assessment, nutrient requirements, food security and rural development. The review provides information to readers working in government institutions, universities, research centres, non-governmental organizations, the food industry and the communications media in 184 countries.

Free subscriptions to this journal may be obtained from the Technical Editor, Food and Nutrition Division, Food and Agriculture Organization, Viale delle Terme di Caracalla, 00100 Rome, Italy (E-mail: fna@fao.org).

UNE PUBLICATION DE LA DIVISION DE L'ALIMENTATION ET DE LA NUTRITION DE LA FAO

Alimentation, nutrition et agriculture traite de domaines dans lesquels s'exercent les activités de la Division de l'alimentation et de la nutrition de la FAO – nutrition de la collectivité, qualité et sécurité sanitaire des aliments, évaluation nutritionnelle, besoins en nutriments, sécurité alimentaire et développment rural. La revue accueille avec intérêt des articles pouvant intéresser ses lecteurs qui travaillent dans les institutions gouvernementales, les universités et les centres de recherche, les organisations non gouvernementales, l'industrie alimentaire et les médias de 184 pays.

Des abonnements gratuits peuvent être obtenus auprès du rédacteur technique, Division de l'alimentation et de la nutrition, FAO, Viale delle Terme di Caracalla, 00100 Rome, Italie (Mél.: fna@fao.org).

UNA PUBLICACIÓN DE LA DIRECCIÓN DE ALIMENTACIÓN Y NUTRICIÓN DE LA FAO

La revista *Alimentación, Nutrición y Agricultura* trata temas de interés para la Dirección de Alimentación y Nutrición de la FAO, incluyendo nutrición de la comunidad, calidad e inocuidad de los alimentos, apreciación y evaluación relacionadas con la nutrición, necesidades de nutrientes, seguridad alimentaria y desarrollo rural. La revista acepta artículos de interés para sus lectores que trabajan en instituciones gubernamentales, universidades y centros de investigación, organizaciones no gubernamentales, así como en la industria alimentaria y en los medios de comunicación de 184 países.

La suscripción gratuita a la revista podrá solicitarse al Redactor técnico, Dirección de Alimentación y Nutrición, FAO, Viale delle Terme di Caracalla, 00100 Roma, Italia (correo electrónico: fna@fao.org).

Design/maquette/gráfica: Maxtudio

Cover photo/photo de la couverture/foto de la cubierta: P. Cenini

ISSN 1014-806X

30
2002

Food, Nutrition and Agriculture
Alimentation, Nutrition et Agriculture
Alimentación, Nutrición y Agricultura

editorial

articles articles artículos

highlights actualité noticias

editorial

Human energy requirements

To combat malnutrition, we must be able to define it. How much food do we need to be healthy at all stages and under all circumstances of life? Setting nutrient requirements is an important step in helping nations answer this question. The expert consultations conducted by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) analyse scientific data to determine nutrient requirements for people throughout the life cycle. Because of changing evidence based on advancing research in the field, more sophisticated measuring techniques and technology, and reinterpretation of existing data, it is important that the issue of nutrient requirements be examined periodically. In October 2001, nutrition experts from around the world participated in the Joint FAO/WHO/United Nations University (UNU) Expert Consultation on Energy in Human Nutrition to make recommendations for human energy requirements.

This issue of *Food, Nutrition and Agriculture* explores issues related to human energy starting with two perspectives on the expert consultation process. The article by Prakash Shetty takes us back to the first expert consultation in 1950 and explains some of the difficult issues addressed by this early group of scientists. In spite of the vast changes that have occurred in the field of nutrition since the 1950s, most of the concepts determined at that consultation are relevant today. However, the field of nutrition has advanced rapidly since the first group of scientists met. Experts at the 2001 consultation challenged previous nutrition concepts by holding them up to the light of an increasing body of scientific enquiry based on sophisticated methodologies such as the stable isotope technique. The next article, by Robert Weisell, points to the spectacular advancement and complexity of the field of nutrition, the increased number of international scientists involved in nutrition research and application, and the political and economic implications of the recommendations, as reasons for a periodic review of the process of the expert consultations.

The advancement of the technology required in nutrition research, while increasing certainty of the measurement of total energy expenditure, has widened the research gap between countries. Because of the high costs of technical training, sophisticated equipment and the isotopes themselves, developing countries have found themselves without the resources to utilize the new methodologies. However, as the article by Eric-Alain Ategbo points out, it is critical that standardized data be collected for all people of all ages from every country if appropriate decisions are to be made relating to global human energy requirements.

Continuing with our energy theme, Benjamín Torún examines the importance of including discretionary activity in the energy requirements of developing country populations. This is followed by the article of Cecilia Albala, Juliana Kain and Ricardo Uauy highlighting the vital role of energy needs for human growth and development by describing the work carried out in Chile to address stunting. Our focus on energy in human nutrition ends with an examination by Gina Kennedy of the status of food energy through the last four decades and highlights specific nutrient balance data by region, economic status and gender.

It is hoped that the information provided in this issue will assist planning to decrease inequities and stimulate policies leading to food security for all people.

Besoins énergétiques humains

Pour lutter contre la malnutrition, il faut pouvoir la définir. De combien de nourriture avons-nous besoin pour être en bonne santé à tous les âges et dans toutes les circonstances de la vie? La détermination des besoins en nutriments est une étape importante pour aider les pays à répondre à cette question. Les consultations d'experts organisées par l'Organisation des Nations Unies pour l'alimentation et l'agriculture (FAO) et l'Organisation mondiale de la santé (OMS) analysent des données scientifiques en vue de déterminer les besoins en nutriments des populations tout au long du cycle biologique. Dans la mesure où les données évoluent avec les progrès de la recherche dans ce domaine, où les techniques d'évaluation et les technologies se perfectionnent et où il convient de réinterpréter les données existantes, il est important de réexaminer périodiquement la question des besoins en nutriments. En octobre 2001, des nutritionnistes du monde entier ont participé à la Consultation mixte d'experts FAO/OMS/Université des Nations Unies sur l'énergie dans la nutrition humaine, afin de formuler des recommandations concernant les besoins énergétiques humains.

Le présent numéro d'*Alimentation, nutrition et agriculture* examine les questions relatives à l'énergie humaine en proposant deux points de vue sur le processus de la consultation d'experts. L'article de Prakash Shetty revient sur la première consultation d'experts, tenue en 1950, et décrit quelques-unes des difficultés auxquelles ce groupe de scientifiques a été confronté. Malgré les changements considérables survenus dans le domaine de la nutrition depuis les années 50, la plupart des concepts énoncés lors de cette consultation restent valables. Toutefois, la recherche en matière de nutrition a bien progressé depuis. Ainsi, les experts réunis pour la consultation de 2001 ont réexaminé les concepts traditionnels à la lumière des résultats d'un nombre croissant d'enquêtes scientifiques fondées sur des méthodologies de pointe comme la technique des isotopes stables. L'article suivant de Robert Weisell met en évidence les progrès spectaculaires et la complexité du domaine de la nutrition, le nombre croissant de spécialistes internationaux qui se consacrent à la recherche et aux applications dans le domaines de la nutrition et aux incidences politiques et économiques des recommandations, qui justifient un examen périodique du processus des consultations d'experts.

Les progrès technologiques nécessaires pour la recherche dans le domaine de la nutrition, qui permettent d'évaluer avec plus de précision la dépense énergétique totale, ont aussi élargi l'écart entre les pays en matière de recherche. A cause du coût élevé de la formation technique, du matériel de pointe et des isotopes eux-mêmes, les pays en développement n'ont pas les moyens d'utiliser ces nouvelles méthodologies. Toutefois, comme le montre l'article d'Eric Ategbo, il est indispensable de recueillir des données normalisées pour tous les individus, de tous âges et dans tous les pays, pour pouvoir prendre des décisions appropriées en matière de besoins énergétiques humains.

Continuant sur le thème de l'énergie humaine, Benjamin Torún examine l'importance d'inscrire l'activité discrétionnaire dans les besoins d'énergie des populations des pays en développement. L'article de Cecilia Albala, Juliana Kain et Ricardo Uauy souligne le rôle essentiel des besoins énergétiques pour la croissance et le développement humains en décrivant le travail effectué au Chili pour remédier au retard de croissance. L'examen de l'énergie dans la nutrition humaine se termine par une étude de Gina Kennedy sur l'état de l'énergie alimentaire au cours des quatre décennies écoulées, et appelle l'attention sur les données relatives à l'équilibre en nutriments par région, par situation économique et par sexe.

Nous espérons que les informations données dans le présent numéro, en facilitant la planification, contribueront à atténuer les inégalités et à promouvoir l'adoption de politiques assurant la sécurité alimentaire de tous.

Necesidades energéticas humanas

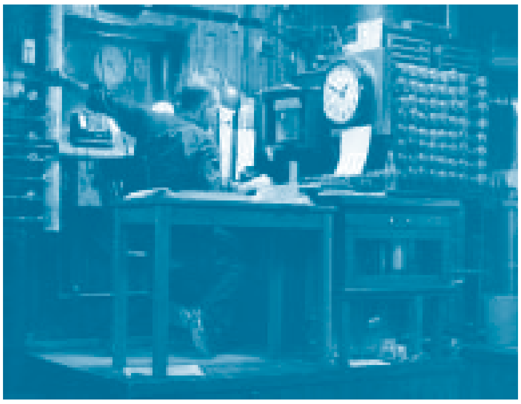
Para combatir la malnutrición, es preciso poder definirla. ¿Qué cantidad de alimentos necesitamos para estar sanos en todas las etapas y todas las circunstancias de la vida? Determinar las necesidades nutritivas supone un paso importante para ayudar a los países a responder a esta pregunta. Las consultas de expertos llevadas a cabo por la FAO y la Organización Mundial de la Salud (OMS) analizan los datos científicos para determinar las necesidades nutritivas de las personas a lo largo del ciclo vital. Debido a los nuevos conocimientos, basados en los progresos de la investigación en este campo, en una tecnología y unas técnicas de medición más sofisticadas y en la reinterpretación de los datos existentes, es importante examinar periódicamente la cuestión de las necesidades nutritivas. En octubre de 2001, expertos en nutrición provenientes de todo el mundo participaron en la Consulta mixta de expertos FAO/OMS/Universidad de las Naciones Unidas (UNU) sobre energía en la nutrición humana para hacer recomendaciones sobre las necesidades energéticas humanas.

En el presente número de *Alimentación, Nutrición y Agricultura* se examinan asuntos relacionados con las necesidades energéticas humanas partiendo de dos perspectivas formuladas en el proceso de las consultas de expertos. El artículo de Prakash Shetty se remonta a la primera consulta de expertos de 1950 y explica algunas de las difíciles cuestiones a las que tuvo que enfrentarse este grupo pionero de científicos. A pesar de los grandes cambios que han tenido lugar en el campo de la nutrición desde el decenio de 1950, la mayor parte de los conceptos definidos en esa consulta son relevantes hoy. Sin embargo, el campo de la nutrición ha avanzado rápidamente desde que se reunió el primer grupo de científicos. En la consulta de 2001, los expertos pusieron en entredicho los conceptos anteriores sobre la nutrición contrastándolos a la luz de un *corpus* creciente de investigación científica basada en tecnologías sofisticadas tales como la técnica del isótopo estable. El siguiente artículo, de Robert Weisell, pone de relieve los considerables avances y complejidad del campo de la nutrición, el aumento del número de científicos internacionales dedicados a la investigación en nutrición y sus aplicaciones, y las implicaciones políticas y económicas de las recomendaciones, las cuales son motivo de revisiones periódicas del proceso de las consultas de expertos.

Los progresos de la tecnología empleada en la investigación sobre nutrición, al tiempo que han aumentado la certeza de las mediciones del gasto total de energía, han ampliado las diferencias entre los países en cuanto a la investigación. Los países en desarrollo se han encontrado sin recursos para utilizar las nuevas metodologías debido a los altos costos de la capacitación técnica, los sofisticados equipos y los isótopos mismos. Sin embargo, como se señala en el artículo de Eric-Alain Ategbo, si se quieren adoptar decisiones apropiadas en relación con las necesidades energéticas humanas en el mundo, es fundamental recopilar datos estándar sobre todas las personas de todas las edades y países.

Continuando con el tema de la energía, Benjamín Torún examina la importancia de incluir la actividad física habitual en los requisitos energéticos de las poblaciones de los países en desarrollo. El artículo de Cecilia Albala, Juliana Kain y Ricardo Uauy pone de manifiesto la función vital de las necesidades energéticas en el crecimiento y desarrollo humanos, describiendo la labor realizada en Chile para luchar contra el retraso del crecimiento. El examen de la energía en la nutrición humana termina con un estudio de Gina Kennedy de la situación de la energía alimentaria durante los últimos 40 años que incluye datos del equilibrio de los elementos nutritivos por región, situación económica y sexo.

Esperamos que la información proporcionada en el presente número ayude a planificar medidas con objeto de reducir las desigualdades y a estimular políticas que permitan alcanzar la seguridad alimentaria a todas las personas.



Penn State University Archives/Armsby Calorimeter

Human energy requirements: where are we now? Issues emerging from the 2001 Expert Consultation on Energy in Human Nutrition

Prakash Shetty
is the Chief of FAO's Nutrition Planning, Assessment and Evaluation Service.

Scientific advances are being made in our understanding of the basis of human energy requirements. As technological advances enable us to obtain better and more accurate estimates of human energy needs, and as our appreciation of the problems associated with deficient and excess energy intakes leading to energy imbalance in humans grows, international agencies mandated to convene expert consultations in this area are confronted with changing scientific concepts and evidence as well as shifts in priorities of member countries' needs. This article explores two important developments – one technological and the other conceptual – that have shifted our understanding of energy balance in humans and hence contributed to changes in the approaches made by a recent expert consultation to review human energy requirements convened by FAO, the World Health Organization (WHO) and the United Nations University (UNU), at FAO headquarters in Rome.

It is useful in this context to provide a brief historical review of the conceptual shifts in this most important area of human energy needs, which will complement the historical outline of the nature of this consultative process reviewed in the article by Dr Weisell (see page 14). The reports of the first two FAO Committees on Calorie Requirements (1950 and 1957) established general concepts, many of which have stood the test of time over the last half-century. The three important concepts established by these two forerunner expert committees were, first, that the energy needs of a group are represented by the average of the needs of individuals in that group. Second, that as far as possible, energy requirements should be determined from estimates of energy expenditure. The third generalization enunciated by these committees, relating to the concept of a "reference" man or woman, has, however, undergone modification over time. Although the concept of a reference man or woman was considered a convenient starting point for extrapolation and not intended to suggest an ideal standard, this concept has been relegated in most instances as being unduly restrictive with the recognition that both body size and physical activity patterns vary worldwide and able and widely usable method was available to the scientific and academic community to collect such data from a range of population groups worldwide.

When the Joint FAO/WHO/UNU Expert Consultation on Energy in Human Nutrition was convened in 2001 in Rome the situation related to the lack of data to arrive at realistic and evidence-based recommendations had dramatically changed. Almost all the recommendations that are likely to be made in the most recent report to be published later in the year 2002 will be based on reliable measurements of total energy expenditure obtained from infants, children, adolescents, adults and the elderly, as well as in special physiological states such as pregnancy and lactation.

ing to the nature and pattern of daily activities.

Doubly-labelled water technique

A major breakthrough in our ability to obtain reliable and accurate estimates of habitual energy expenditure was the application of the doubly-labelled water (DLW) technique to humans under free-living conditions.

A major breakthrough in our ability to obtain reliable and accurate estimates of habitual energy expenditure was the application of the doubly-labelled water technique to humans under free-living conditions

undergo dramatic changes over time.

The 1973 Report of the Joint FAO/WHO Ad Hoc Expert Committee on Energy and Protein Requirements reiterated statements that had been made in the past by expert groups that recommendations for nutrient requirements should be applied to groups and not to individuals. However, the 1973 report also made two additional important points: (a) that estimates of requirements are derived from individuals rather than groups; and (b) that the nutrient requirements of comparable individuals often vary.

The 1985 report was very clear in its statement that estimates of energy requirements should, as far as possible, be based on estimates of energy expenditure, since the prevailing method of determination – from observed intakes of food energy – was becoming unreliable and at the same time served to support a circular argument that access to food determined energy needs. The rationale for this conclusion was that both in developing and developed countries actual energy intakes are not necessarily those that either maintain a desirable body weight or provide for optimal levels of physical activity and hence health in its broadest sense. The experts at the 1985 consultation were aware of the limited data on energy expenditures, particularly among children. They were also conscious of the fact that no reli-

Measurement of energy expenditure and its implication for estimating energy requirements

In the last two decades, major technological advances using stable (i.e. non-radioactive) isotopes have had a dramatic impact on the measurement of energy expenditures of free-living individuals in real-life situations. Estimates based on these measurements have replaced, to a large extent, the estimates using both direct and indirect calorimetry and the associated dependent methodologies such as heart rate monitoring, activity monitoring, pedometers and actometers. It is important to reiterate that these conventional methods continue to be important because the stable isotope technique measures cumulative total energy expenditure over a period of time and provides no accurate estimate of day-to-day variations or information relat-

This method was developed in the early 1950s by Lifson and McClintock (1966) to estimate the energy output of small animals. During the first ten years of its use in humans, the DLW method was extensively validated and is now considered to be the "gold standard" for the measurement of total energy expenditure (TEE) of humans throughout the life cycle, from newborn infants to the very elderly. Although metabolic rate and the energy cost of different activities have been measured and daily energy expenditures of individuals computed from this in both developed and developing country settings, the measurement of habitual TEE by unrestrained, free-living individuals in real-life situations in their normal surroundings has had to await the use and validation of the DLW method.

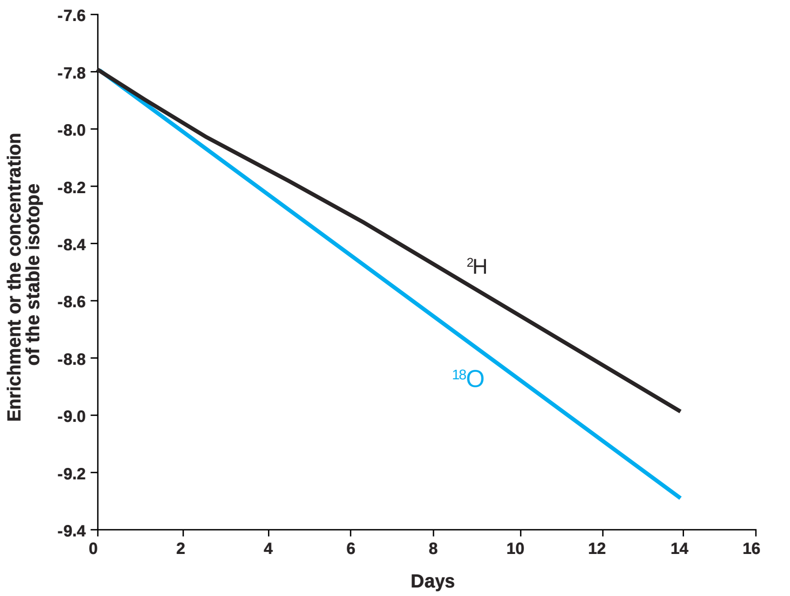
The DLW technique for measuring TEE involves enriching the water within the body with the use of water labelled with a stable isotope of hydrogen (i.e. deuterium, ^{2}H) and a stable isotope of oxygen (i.e. ^{18}O). Following the administration of such doubly-labelled water, the manner in which these two isotopes are differentially washed out of the body over time is determined. The difference in the rate of excretion or washout of the isotopes from the body is a measure of the amount of carbon dioxide (CO_2) produced over that period of time (Figure 1) from which the oxygen consumption and hence energy expended over the same time period can be computed. The concentration of labelled hydrogen, i.e. deuterium (^2H), decreases as a result of the dilution of the water in the body from unlabelled water consumed every day (in food and drink), by the addition of metabolic water produced as a result of oxidation of nutrients and by the loss of labelled water in urine, sweat and other excretions, and evaporative loss from the lungs. Deuterium is hence lost only in the water that moves through the body. Thus, the slope of the decay or loss of the deuterium in body water is a measure of water movement through the individual.

The process is slightly different for the stable isotope of oxygen (^{18}O). Most of the labelled oxygen is lost as oxygen in the water molecule, but some is also lost as oxygen in the CO_2 molecule that is produced. Some of the labelled oxygen is seen in carbonic acid, or the bicarbonate formed by the dissolving of CO_2 in body water. The labelled oxygen, ^{18}O, therefore disappears from the body through two pathways, i.e. in CO_2 and in water, unlike the single pathway of disappearance of the hydrogen isotope, ^2H. Thus the slope of washout of ^{18}O from the body is steeper than that for deuterium (see Figure 1). The differences in the washout slopes of ^{18}O and ^2H are a measure of the production of CO_2 over this period of time. This indirect measure of metabolic rate (indirect because hitherto it has been the convention to measure oxygen consumption by the body to estimate energy expenditure or heat production) may then be converted to units of heat production from estimates of the chemical composition of food being oxidized since the chemical composition of food determines the energy equivalent of each litre of CO_2 produced by the body as it expends energy.

The methodology using the DLW technique involves the administration of carefully weighed doses of ^{18}O and deuterium to the subject followed by the collection of urine or saliva samples over time periods ranging from several days to several weeks depending on the rate at which the water moves through the body. For instance, in tropical climates, large amounts of water are consumed and excreted mostly as sweat, and hence the rate of movement or turnover of water is much higher. In the early studies in temperate climates, samples were collected on a daily basis and analysed. However, it has since been shown that a minimum of two post-dose samples – one within hours of administration and the other at the end of several days or weeks – would suffice. Since the method of estimation of the isotopes in the sample using mass spectrometers is time-consuming and expensive, this represents an important saving in both costs and time. The specimens or samples are not radioactive, the stable isotopes do not decay over time and the samples are readily transportable as long as they are well sealed. These properties make it possible for specimens to be transported to countries where facilities exist to analyse the samples for isotopic enrichment. DLW thus has several advantages

FIGURE 1

Disappearance rates of ^2H and ^{18}O from body water



Note: The lines demonstrate the disappearance rates of the two isotopes (^{18}O and ^2H) from the body water when estimated from either saliva or urine samples. The rate of disappearance of ^{18}O is much faster since some of the isotope is also lost through the CO_2 excreted from the body. The difference between the two disappearance lines provides a measure of CO_2 production from which the total energy expenditure is estimated.

TABLE 1

Advantages and limitations of the doubly-labelled water technique

Advantages	Limitations
Provides an estimate of habitual TEE in free-living individuals	Does not provide data on day-to-day changes in TEE
Provides an estimate of cumulative TEE over a period of time	Does not provide data on the daily pattern of physical activity
Safe (non-radioactive) for studies in pregnancy, infancy and the elderly	Stable isotope expensive and in short supply
Easy to administer to infants and the very elderly	Analytical equipment and infrastructure expensive
Easy collection of samples (saliva or urine) for analysis	
Easy sample storage and transport for analysis	
Provides a measure of body composition of the subject	
Can be used to estimate maternal breast milk output and milk consumption by breastfed infants	

More effort to help developing countries with the DLW technology and other appropriate technologies was identified as a priority

(summarized in Table 1) but it is important to recognize that the method also has limitations. The DLW technique is expensive as it requires the use of sophisticated equipment to estimate concentration of the isotope. In addition, there is a global shortage of ^{18}O, which has driven its price beyond the reach of most investigators.

The DLW technique of measuring TEE permits the determination of habitual free-living energy expenditure integrated over a period of days (usually between 7 and 20). The first data from humans were published in 1982 (Schoeller and van Santen, 1982). Between 1982 and 1994 sufficient data on TEE in human subjects were accumulated to form the basis for its use in arriving at energy requirements. A database of 1 614 DLW measurements from 1 156 individuals (aged 2 to 90 years) was collated and comprehensively analysed in 1995 (Black *et al.*, 1996). The main analysis was made using a subset of 574 subjects for whom both TEEs by DLW and basal metabolic rate (BMR) measurements were available, under normal free-living conditions, although exclusively from subjects from affluent societies in the developed world. Three years after this compilation, it was estimated that the number of subjects on whom DLW measurements of TEE were available had tripled (Schoeller, 1999). The expert consultation of 2001 benefited for the first time from this large database of actual estimates of TEE throughout the life course, from infancy to adulthood and the elderly, using the DLW technique.

The number of studies carried out using the DLW technique in the developing countries is limited. A review by Coward (1998) provided an analysis of DLW data from 12 published papers. Since then there have been limited publications from the developing world, such as Kurpad, Borghona and Shetty (1997) and Borghona, Shetty and Kurpad (2000). These two latter studies address the issues that were raised by Coward (1998) when he lamented the lack of DLW data from well-nourished individuals in the developing world, largely as a result of the interest of investigators in taking measurements from the relatively poorly nourished labouring classes in the developing countries. It is evident that more data need to be generated in a systematic way from the developing countries if DLW estimates of TEE are to be used as the basis for arriving at energy requirements of adults worldwide.

Implications of DLW measurements for the recent expert consultation

The DLW technique is an important technological advance that is now considered the gold standard for the estimation of TEE. It provided the 2001 Expert Consultation on Energy in Human Nutrition with the enormous database of TEE measurements needed to arrive at evidence-based recommendations for human energy requirements, from newborn infants to the very elderly, and to assess the increased physiological needs during pregnancy and lactation. This recent consultation reiterated very strongly that energy requirement estimates need to be based on measurements of energy expenditure and not intakes. It reconfirmed the view that estimates of energy requirement refer to groups and not to the individual *per se* and that these recommendations for energy requirements of individuals are the mean of the group with no safe margin as with other nutrients. According to the 2001 consultation, the DLW method is accurate and should be the method of choice for estimating TEE; it should be used to validate the results obtained by other methods.

The current limitations relative to the cost and availability of ^{18}O as well as lack of expertise and infrastructure to undertake DLW measurements, especially in developing countries, need to be addressed urgently. More effort to help developing countries with the DLW technology and other appropriate technologies was identified as a priority.

The 2001 consultation also made a strong plea that when DLW measurements are taken to assess TEE, information on the lifestyle and the pattern of activities over a day should also be recorded. The pattern and level of physical activities undertaken by individuals are important given the reductions in levels of activity both in the occupational and social spheres of urbanized modern lifestyles. These increasingly sedentary lifestyles are contributing to the problem of obesity in developed industrialized countries and are now also appearing in developing societies, particularly in urban settings.

The data obtained by using the DLW method were considered a valuable resource for the estimation of the TEE of infants. Although this database was derived almost exclusively from studies in the developed world, the assumption that the requirements of infants for normal growth and development are the same worldwide provided the basis for energy recommendations for infants. Evidence had been emerging that the energy requirements of infants are lower than previously recommended, a view that was considered revolutionary in earlier consultations. However, evidence of TEE in infants based on DLW supports the view that energy requirements of infants needed to be lowered, as the 2001 consultation has now done.

Consideration of the concept of "adaptation" when estimating energy requirements

The 1981 expert consultation considered issues related to the concept of "adaptation" when estimating energy requirements to be important. This is evidenced by the number of pages devoted to this topic in the 1985 report, which provided a working definition of adaptation as: "a process by which a new or different steady state is reached in response to a change or difference in the intake of food and nutrients". The 1981 consultation had to wrestle with this concept largely because of the need to deal with the problem of variations in the energy intakes of individuals, both inter- and intra-individual. In addition, they were confronted with data from food consumption surveys that showed that individuals were living active lives on energy intakes that were considerably lower than those hitherto recommended on physiological grounds. The 1985 report considered both short- and long-term adaptations and made three general points with regard to adaptation: (i) that the concept of steady state was relative; (ii) that adaptations may be fundamentally of different kinds – metabolic, genetic and behavioural; and (iii) that adaptation implied a range of steady states and hence it was impossible to define a single point within the range that represented the "normal" state. The last general point implied that different adapted states will carry different advantages and penalties and hence the decision of what is "optimal" or preferable can only be made in the light of a value judgement. Clearly, this concept of a range of adapted states introduced a dilemma, since it follows that requirements cannot be specified on physiological grounds alone and may need to be based on value judgements made about what is considered desirable to achieve. The accumulation of considerable physiological and other scientific evidence in the interim period of nearly two decades has, however, resolved this issue such that the concept of adaptation is no longer considered significant when recommending energy requirements.

The concept of adaptation in energy metabolism arose out of evidence that the energy metabolism of individuals is variable and adaptable. Several publications had drawn attention to the possibility of such physiological variability in energy utilization between individuals. Norgan (1983) has, however, critically evaluated the evidence that was used to support the concept of adaptation in human energy metabolism and concluded that differences in body size and levels of physical activity may provide explanations for most of these observations. It was also shown that the principal response to a lowering of energy intake in adults depended on the previous nutritional status of the individual (Shetty, 1999).

The reported low energy intakes from food consumption studies conducted in developed and developing countries are now known to be unreliable and physiologically unsustainable

In well-nourished adults, low energy intakes lead to the utilization of body tissue to meet energy needs and with a physiological response suggestive of increased metabolic efficiency. The reduction in body weight coupled with a small increase in efficiency will lower energy expenditure. Daily energy expenditure is lowered by a lower cost of physical activity, largely contributed by the reduction in body weight but also by reduced voluntary activity. There is little evidence of any improvement in the mechanical efficiency of work.

The response to marginal intakes or deficient diets in developing countries is compounded by an increased predisposition to infections and a generalized environmental deprivation. The effects of such undernutrition from birth through the developmental phases into adulthood are

FAO/19197/P. Johnson

closely interlinked with both the immediate effects of childhood malnutrition and the evolution of adult undernutrition later in life. The principal response is a reduction in body size, which persists into adulthood as short stature, low body weight and a reduced muscle mass and fat stores. There is thus little evidence of an increase in metabolic efficiency or an enhanced mechanical efficiency of work in these individuals. Behavioural responses contribute to alterations in physical activity patterns and, along with the small body size, contribute much to reducing energy expenditure to balance the lower levels of intake. However, the compromised body size, altered physical activity patterns and reduced potential to carry out economically productive work have major costs – human and social – that the individual and society will have to bear.

The reported low energy intakes from food consumption studies conducted in developed and developing countries are now known to be unreliable and physiologically unsustainable. These low intakes are often just above or below the basal or resting energy levels and provide for nothing more than a day lying in bed. They are unlikely to reflect the true intakes of individuals who are leading an active life. DLW studies, when conducted in such supposedly low-intake individuals, have clearly shown that such intakes are unsustainable over the short (i.e. a few days) or the long (i.e. a few weeks) term without serious loss of body weight. The TEE estimates by DLW in these individuals provided evidence of serious underreporting of energy intakes (Goldberg and Black, 1998). This evidence has more or less settled the debate on whether adaptation can be considered a serious enough physiological mechanism to adjust to lowered energy intakes when individuals continue to maintain their body weights and habitual physical activity levels.

The idea of costless adaptation was rejected with the recognition that there will always be a consequence to low energy intakes both in physical terms, i.e. low body weight, height or altered body composition, and in terms of compromises in physical activity

Implications of the concept of adaptation for the 2001 expert consultation

The dilemma that confronted the 1981 expert consultation when they had to wrestle with the concept of adaptation to variations in energy intake was not an issue at the expert consultation held at FAO in Rome in October 2001. The recent consultation was confronted with scientific evidence accumulated over the last 20 years, which indicated that while metabolic adaptation and improvements in metabolic efficiency may occur during energy restriction of individuals, this was of a trivial nature and could not form the basis for any alteration in an individual's requirements for energy. It was also observed that there were costs to this adaptation, which may manifest in an increased risk of infection and disease. The 2001 consultation recognized that while behavioural adaptation did in fact take place to a considerable extent, it was at a cost to the individual in terms of reductions in socially desirable activities. The costs to the individual and to society were compromises that should not be reflected in recommendations of energy requirements. Thus the question of adaptation that occupied the minds of the expert consultation in 1981 was not an issue when the 2001 expert consultation deliberated on energy requirements 20 years on.

The idea of costless adaptation was rejected with the recognition that there will always be a consequence to low energy intakes both in physical terms, i.e. low body weight, height or altered body composition, and in terms of compromises in physical activity.

In conclusion, two examples have been used in this article to show how technological advances and the accumulation of good scientific evidence inform the debates of expert consultations and result in new reports from time to time – an essential normative function of United Nations agencies such as FAO to fulfil their mandate to the member countries.

bibliography

Black, A.E., Coward, W.A., Cole, T.J. & Prentice, A.M. 1996. Human energy expenditure in affluent societies: analysis of 574 doubly-labelled water measurements. ***Eur. J. Clin. Nutr.***, 50: 72–92.

Borgonha, S, Shetty, P.S. & Kurpad, A.V. 2000. Total energy expenditure and physical activity level in chronically energy deficient Indian males measured by the doubly labelled water technique. ***Indian J. Med. Res.***, 111: 138–46.

Coward, W.A. 1998. Contributions of the doubly labeled water method to studies of energy balance in the Third World. ***Am. J. Clin. Nutr.***, 68: S962–S969.

FAO. 1950. ***Calorie requirements: report of the Committee on Calorie Requirements***. FAO Nutritional Studies No. 5. Washington, DC.

FAO. 1957. ***Calorie requirements: report of the Second Committee on Calorie Requirements***. FAO Nutritional Studies No. 15. Rome.

FAO/WHO. 1973. ***Energy and protein requirements: report of the Joint FAO/WHO Ad Hoc Expert Committee***. FAO Nutrition Meetings Report Series No. 52, Rome, and WHO Technical Report Series No. 522, Geneva.

Goldberg, G.R. & Black, A.E. 1998. Assessment of the validity of reported energy intakes – review and recent developments. ***Scand. J. Nutr.***, 42: 6–9.

Kurpad, A.V., Borgonha, S. & Shetty, P.S. 1997. Measurement of total energy expenditure by the doubly labelled water technique in free living Indians in Bangalore city. ***Indian J. Med. Res.***, 105: 212–219.

Lifson, N. & McClintock, R. 1966. Theory of the use of the turnover rate of body water for measuring energy and material balance. ***J. Theor. Biol.***, 12: 46–74.

Norgan, N.G. 1983. Adaptation of energy metabolism to level of energy intake. ***In*** J. Parizkova, ed. ***Energy expenditure under field conditions,*** pp. 56–64. Prague, Charles University.

Schoeller, D.A. 1999. Recent advances from application of doubly labelled water to measure human energy expenditure. ***J. Nutr.***, 129: 1765–1768.

Schoeller, D.A. & van Santen, E. 1982. Measurement of energy expenditure in humans by doubly labelled water method. ***Am. J. Physiol.,*** 53: 955–959.

Shetty, P.S. 1999. Adaptation to low energy intakes: the responses and limits to low intakes in infants, children and adults. ***Eur. J. Clin. Nutr.***, 53: S14–S33.

WHO. 1985. ***Energy and protein requirements: report of the Joint FAO/WHO/UNU Expert Consultation***. WHO Technical Report Series 724. Geneva.

summary | résumé | resumen

P. SHETTY

Human energy requirements: where are we now? Issues emerging from the 2001 Expert Consultation on Energy in Human Nutrition

Scientific advances are continuously adding to our knowledge of food and nutrition. Technological advances such as the doubly-labelled water technique now enable us to obtain accurate estimates of habitual energy expenditure in free-living conditions. The data acquired using this technique have complemented other information from conventional methods to inform the 2001 Expert Consultation on Energy in Human Nutrition to arrive at evidence-based recommendations. Scientific evidence from studies conducted in different parts of the world have made it possible for the experts to evaluate the importance of adaptation to variations in energy intake while considering its relevance to recommendations for requirements of energy. Expert consultations on nutrient requirements, such as those convened under the mandates of international agencies such as FAO, are confronted with changing scientific concepts based on the application of new technology or on a better understanding of the physiological mechanisms, which influence the recommendations made in their reports. This article explores two important developments – one technological and the other conceptual – that have both contributed to shifts in the approaches made by the recent expert consultation to review human energy requirements convened at FAO headquarters in Rome.

Besoins énergétiques humains: où en sommes-nous actuellement? Questions se dégageant de la Conférence d'experts de 2001 sur l'énergie dans la nutrition humaine

Grâce au progrès scientifique, notre connaissance des processus alimentaires et nutritionnels ne cesse de s'améliorer. Des progrès technologiques, comme la technique de l'eau à double étiquetage, nous permettent désormais d'obtenir des estimations exactes de la dépense énergétique habituelle d'une personne menant une vie normale. Les données acquises à l'aide de cette technique complètent d'autres données obtenues avec des méthodes traditionnelles qui ont permis à la Consultation d'experts de 2001 sur l'énergie dans la nutrition humaine de formuler des recommandations fondées sur des preuves scientifiques. Celles-ci, qui résultent d'études menées dans différentes régions du monde, ont permis aux experts d'évaluer l'importance de l'adaptation de l'organisme aux variations de l'apport énergétique et d'en tenir compte dans leurs recommandations concernant les besoins énergétiques. Les consultations d'experts sur les besoins en nutriments, comme celles convoquées dans le cadre d'organisations internationales comme la FAO, sont confrontées à des concepts scientifiques en perpétuelle évolution, compte tenu de l'application de nouvelles technologies ou d'une meilleure compréhension des mécanismes physiologiques, qui influencent les recommandations formulées dans le rapport. Le présent article étudie deux progrès importants – l'un technologique, l'autre théorique –, qui ont conduit à une modification de l'approche adoptée par la récente consultation d'experts tenue au siège de la FAO, à Rome, pour étudier les besoins énergétiques humains.

Necesidades energéticas humanas: ¿cuál es la situación actual? Cuestiones discutidas en la Consulta de expertos sobre energía en la nutrición humana 2001

Los progresos científicos están enriqueciendo constantemente los conocimientos sobre los alimentos y la nutrición. Actualmente, los avances tecnológicos, tales como la técnica del agua doblemente marcada, permiten hacer cálculos precisos del gasto energético habitual en condiciones de vida normales. Los datos

obtenidos utilizando esta técnica han completado otras informaciones obtenidas mediante métodos convencionales, que han permitido a la Consulta de expertos sobre energía en la nutrición humana de 2001 llegar a recomendaciones basadas en las observaciones. Gracias a las pruebas científicas derivadas de investigaciones realizadas en diferentes partes del mundo, los expertos han podido evaluar la importancia de la adaptación a las variaciones en la ingesta energética y considerar al tiempo su pertinencia a la hora de hacer recomendaciones sobre las necesidades energéticas. Las consultas de expertos sobre las necesidades nutritivas, como las convocadas con arreglo a los mandatos de los organismos internacionales como la FAO, se enfrentan a conceptos científicos cambiantes, basados en la aplicación de la nueva tecnología o en el mejor entendimiento de los mecanismos fisiológicos que influencian las recomendaciones hechas en sus informes. Este artículo analiza dos novedades importantes, una tecnológica y otra conceptual, que han contribuido al cambio en los enfoques realizado por la consulta reciente de expertos convocada en la sede de la FAO, en Roma, a fin de examinar las necesidades energéticas humanas.